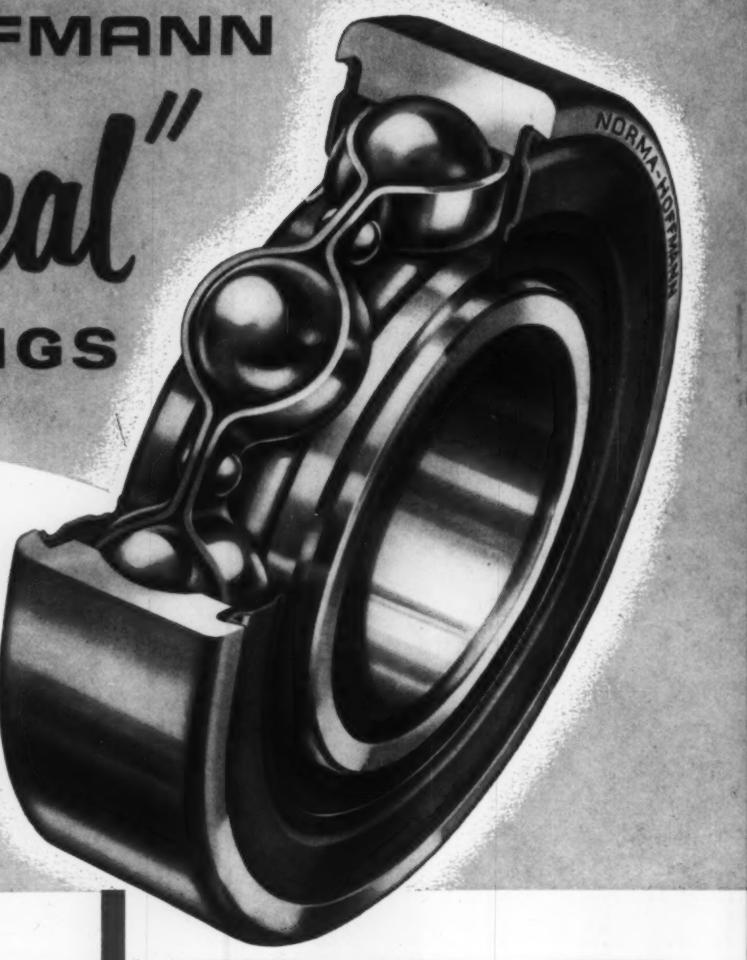
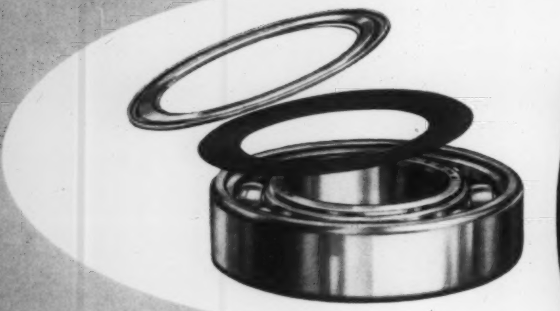
20,

MACHINE DESIGN

NORMA-HOFFMANN
"Plastiseal"
BALL BEARINGS





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Maximum Sealing with Minimum Friction

Norma-Hoffmann "*Plastiseal*" Ball Bearings keep out damaging dirt and retain full lubrication. That's because they're made with oil and grease resistant synthetic rubber seals, firmly attached to the outer ring, with very light rubbing contact on the inner ring's smooth recess.

Other Norma-Hoffmann "Plastiseal" advantages include:

- Low seal friction insuring low wattage and freedom from wear.
- Compact design for completely sealed bearings.
- Prepacking with metered quantity of wide temperature range grease.

For complete details on Norma-Hoffmann's "*Plastiseal*" Ball Bearings, write now for catalog.

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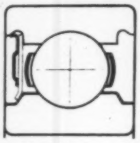
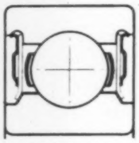
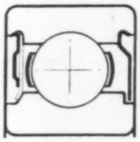


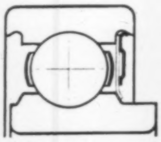
"K" Series
with Single Rubber Seal



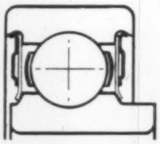
"KK" Series
with Double Rubber Seal



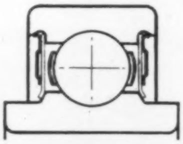
"KP" Series
with Single Rubber Seal and Metal Shield



"8000-K" Series
with Single Seal and Extended Inner Ring



"8000-KK" Series
with Double Seal and Extended Inner Ring



"88000-KK" Series
with Double Seal and wide Inner Ring

Circle 401 on Page 19

precision ball, roller & thrust bearings

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BEARINGS CORPORATION • STAMFORD, CONN.
founded 1911

The BODINE line— a complete line of fractional hp motors

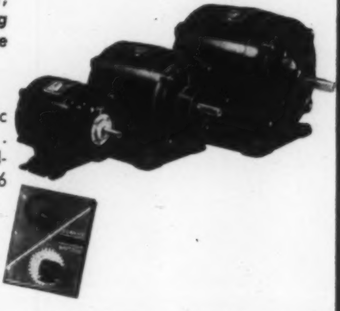
Over 3500 standard motors—built to order—only 12- to 16-week delivery

...for blowers, pumps, coin-handling units, communication equipment, therapeutic devices, sound-recording and reproducing equipment, machine tools, and similar applications

BODINE TYPE N MOTORS

These motors are available in three basic sizes... the smallest 3⅜" in diameter... the largest 5½". Almost any type winding. Standard ratings from 1/150 to 1/6 hp at 1725 rpm.

Write for bulletin "S"



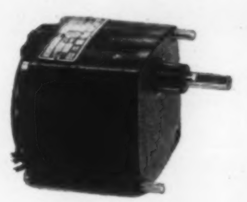
...for instruments, timing devices, control apparatus, and related equipment

BODINE TYPE K-2 MOTORS

Available with and without speed reducers. Model without reducer ideal for equipment requiring relatively low output. Overall height only 2⅜". Instantly reversible. Can be stalled indefinitely. Synchronous or non-synchronous. Normal 60-cycle output ranges from 1/2000 to 1/500 hp on continuous duty.

Models with parallel shaft speed reducer have high starting torque of not less than 150% of full load torque at room temperature. Quickly reversible under load. Synchronous or non-synchronous. Drive shaft speeds range from 300 to 0.7 rpm...torque ratings from 1.3 in. oz. to 120 in. oz.

Write for bulletin 1024A
...for speed reducer models, bulletin 1023B



...for use in office machines, automatic phonographs, circulating pumps, air conditioning equipment, and similar applications

BODINE TYPE U MOTORS

"U" type motors are available in 1/20 and 1/15 hp at 1725 rpm...and in 1/30 hp at 1125 rpm. Diameter 4⅜". Split-phase construction. Resilient mounting for quiet operation. Thermal overload protection.

Write for bulletin 1028

265 different stock types and sizes ready for fast shipment!

BODINE ELECTRIC CO., 2258 W. OHIO ST., CHICAGO 12

BODINE
fractional / horsepower
MOTORS

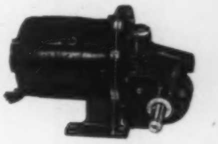
...the power behind the leading products

BODINE SPEED REDUCER MOTORS

...combines motor and speed reducer in one unit, eliminating all cumbersome and complicated speed reducer transmissions such as belts, gears, and chains

...single or double reduction speed reducers for transmitting low torques over a wide range of speeds. Height, 3⅝".

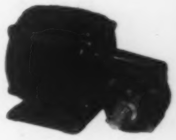
...double worm-gear reducer to deliver moderate torques at low speeds. Height, 4¾".



...single reduction, right angle worm gear reducer to deliver moderate torques. Height, 4⅞".

...double worm-gear reducer for transmitting high torques at low speeds. Height, 6⅞".

...single reduction, right angle worm gear reducers for transmitting substantial torques. Height, 6 3/64".

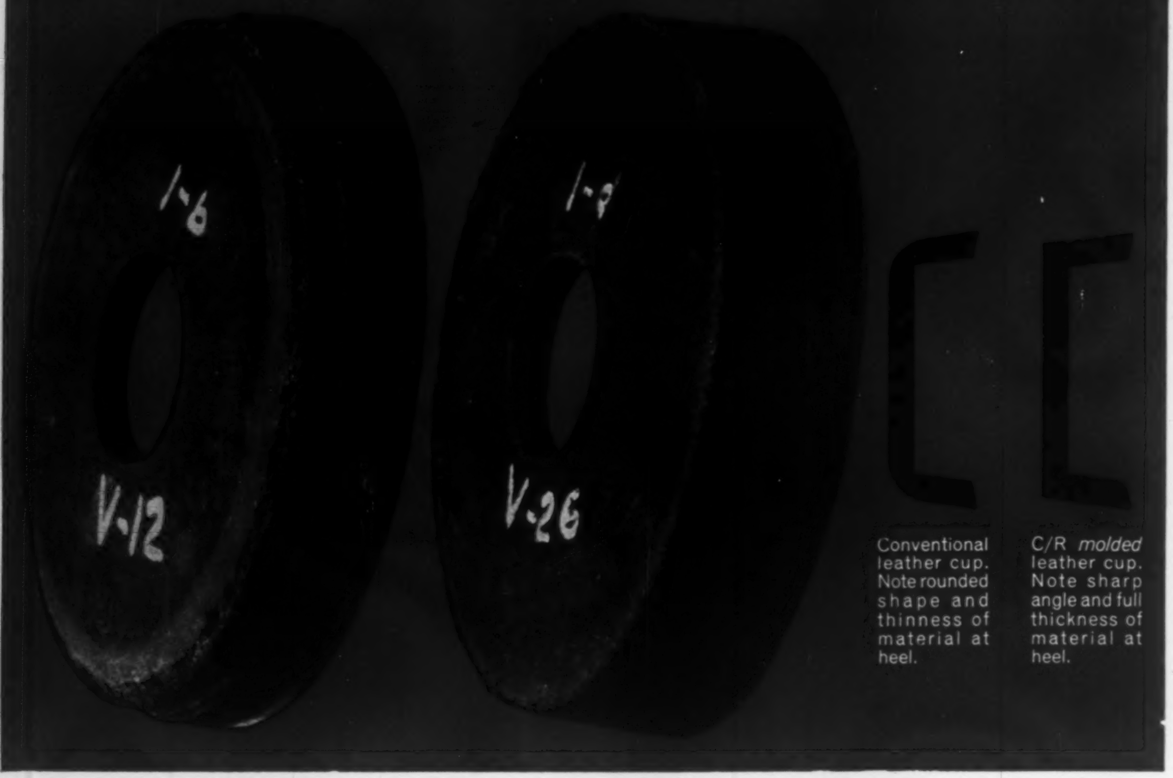


...heavy duty reducer for continuous driving of heavy loads. Ample reserve for overloads. Height 7⅞". Eight different windings.

Write for bulletin 1022B

Circle 404 on Page 19

TEST PROVES C/R MOLDED CUP



Conventional leather cup. Note rounded shape and thinness of material at heel.

C/R *molded* leather cup. Note sharp angle and full thickness of material at heel.

New molded C/R cups* stand up longer... cut down replacement costs

Compare the wear on these piston cups shown in the unretouched photographs above. They were tested in a hydraulic cylinder at 6000 p.s.i. for 3000 cycles. The one at the right is a Sirvis-Conpor molded leather cup. The other is a conventional leather cup. Features of the C/R molded cup that make it so obviously superior are greater density, the sharp, rather than rounded heel, and the fact that it is pre-formed to the shape which conventional cups are forced to assume under pressure. This eliminates operational stress and flexing that conventional cups undergo, and contributes greatly to longer service life.

**Available in J.I.C. standard and other popular sizes. Write for complete size list.*

Right now, molded C/R cups are providing greatly increased service life in hydraulic cylinders in such heavy duty applications as farm and road building equipment and steel mill equipment at oil pressures up to 3500 p.s.i., and 150 p.s.i. in air cylinders. If you face a difficult packing problem that requires high durability and efficiency . . . it will pay you to consider this new, improved C/R design.

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SIRVIS C/R DIVISION
CHICAGO RAWHIDE

Other C/R Products

C/R Shaft & End Face Seals • Sirvene (synthetic rubber) molded pliable parts • C/R Non-metallic Gears

Circle 405 on Page 19

Front Cover: The engineering symbols for a synchronous motor and electrical contacts are combined by George Farnsworth to characterize R. R. Gobeli's article on Page 138.

February 20, 1958

Trucks: The Stylish Stouts 22

NEWS REPORT—A roundup of comments and opinions from four automotive style experts on latest trends and objectives in truck design and appearance.

Reduce Drafting Drudgery 26

NEWS REPORT—Some practical facts on how to increase drafting efficiency as determined by a German research study of methods and equipment.

More Helpful Research Reports 29

NEWS REPORT—Suggestions on how to improve technical reports and communications.

The Superfluous Engineer 30

NEWS REPORT—*Organizing for Productivity, No. 4*—Stockpiling of engineers, its causes and cures in large and small industrial and government projects.

Research + Engineering + Markets 128

PHILIP R. MARVIN—Purpose, duties and organization of a commercial development group for evaluating and steering new product programs.

Starting Synchronous Motors 138

R. R. GOBELI—A review of starting methods and factors affecting selection and application of controls for single-speed, polyphase synchronous motors.

Professional Prestige 147

EDWIN C. NEVIS—*The Personal Side of Engineering*—An analysis of the status of the engineering profession today and how it can be raised.

Transient Response of Servo Systems 148

J. M. NIGHTINGALE—*Transient Response from Transfer Functions*—Concepts and principles of approximate methods for analyzing servo response characteristics.

Precision Gear Trains 156

FRANK WILLIAM WOOD JR.—Principles of a simplified approach to design of low-cost gear assemblies built to order with modular units.

Network Diagrams 163

WILL J. WORLEY—How to construct and use nomographs or network diagrams to speed repetitive calculations in the solution of engineering problems.

Thin-Wall Plastic Parts 171

BENNETT NATHANSON—A review of practical considerations in the design of plastic parts for maximum savings in materials without sacrificing performance strength.

Structural-Test Models 175

H. D. TABAKMAN—*Data Sheet*—Relationships for finding the different scale factors that connect the behavior of a reduced-size model with its prototype.

CONTINUED NEXT PAGE

THE PROFESSIONAL JOURNAL FOR ENGINEERS & DESIGNERS

MACHINE DESIGN

February 20, 1958

Volume 30—No. 4

The Lone Wolf 127
COLIN CARMICHAEL—*Editorial*

Engineering News 6
First U. S. jet airliner, the Boeing 707—engineer motivations survey—transfer mechanism in self-winding watch—cutting lead time in Air Force developments—gasoline blending pump—Z-drive boat engine—national technical documents center—computer for simulation of car operation.

Scanning the Field for Ideas 134
Energy-transfer mechanism—ring construction of rotor and stator assemblies—solid-state photoelectric system—movable cam-follower system for phase adjustment—screw-rotor design for compressor application.

Design in Action 159
Air turbine drives brushes in high-speed rotary polisher—transistorized ac microammeter uses clamp-type pickup probe—"Station Wagon" outboard motor boat has electrically retractable top.

Tips and Techniques

Sum of squares 146
Construction aid 146
Simplified scaling 158
Determining slopes 158

Design Abstracts 179
Steel-Foil Corrugated Panels 179
High Strength Steel Weldments 181
New DC Armature Winding 184

New Parts and Materials 202

Engineering Department Equipment 238

The Engineer's Library 243

Noteworthy Patents 250

Meetings and Expositions 44

Helpful Literature 188
Subject Index 17
Reader Service Cards .. 19
Advertising Index 267
Business Staff 267

IN THE NEXT ISSUE: The latest in dictation equipment . . . how companies train their engineers . . . a guide to technical illustration . . . properties and applications of urethane rubber . . . characteristics of roller bearings . . . inserts for die-castings

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As a production man, I've tried them all. B&W Tubing consistently leads in ease of machining—keeps our operations on schedule."

B&W welded or seamless tubing—in carbon, alloy or stainless steel—offers the right physical and mechanical tubing characteristics for your method of manufacture.

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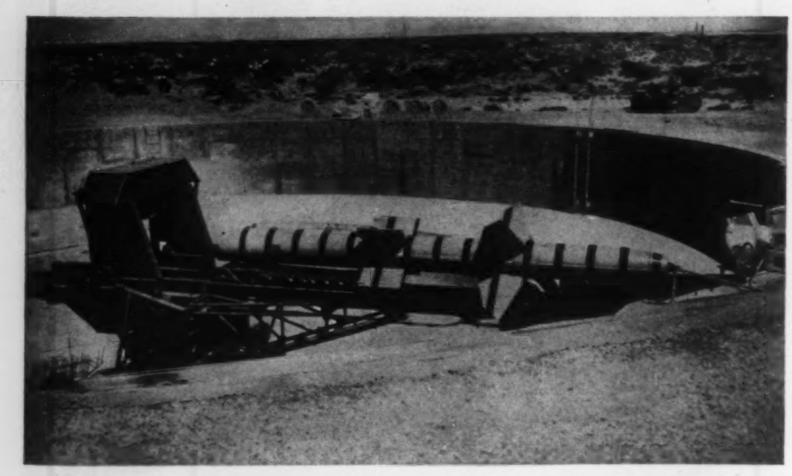
Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals.

Circle 406 on Page 19

ENGINEERING NEWS



FAST FIRING of the Talos air-defense missile is possible with new automatic loading and launching equipment developed by American Machine & Foundry. Each defense unit contains two automatic launchers with surrounding ring of storage cells. Upon activation by computers in the control station, the launcher turns toward the cell in the circular storage magazine that contains the desired type of missile (conventional or nuclear). A cart runs out to the preselected cell, picks up a missile and returns to the launcher. Missile is then positioned, elevated, and rotated to firing position. After firing, launcher automatically recycles for the next round.

NO HANDS are required to load this four-engine Hercules transport, as $17\frac{1}{2}$ tons of palletized freight is rolled aboard in a matter of seconds. Plane can be fully loaded, secured, and ready to fly in 15 min. Cargo, tied to individual pallets in 7000-lb loads, is stored in warehouse on rollers. From warehouse it moves easily to trucks which have truck bed rollers, and is finally pulled, by electric winch, into the cargo hold of the plane —which has rollers on the floor. Although the equipment is familiar to most freight handlers, the system is a new attempt to speed air-freight service. It has reduced manpower needs by 40 per cent; idle ground time by 90 per cent. Lockheed builds the propjet Hercules.

Soviet Gains in Army Weapons Cited by U. S. Observers

Emphasis Not All ICBM's Entire Army Re-Equipped

WASHINGTON — Soviet Army advances in weapons and combat vehicles point to massive efforts by the Russians to equip their troops with the most modern conventional weapons as well as the much-publicized long-range ballistic missiles. Visual evidence and technical estimates, gathered at the November, 1957, Moscow parade, are discussed in the most recent issue of the *Army Information Digest.*

According to the *Digest,* weapons and equipment displayed by the Soviet Army are of the highest quality; firepower is second to none.

The weapons and vehicles unveiled include:

A 15-mile rocket, mounted and launched from a full-tracked amphibious vehicle.

A 35-foot surface-to-surface missile mounted on a modified JSU heavy tank chassis plus a launcher fitted with a U-shaped platform for vertical launching.

A 300-mile mobile ballistic missile of the type developed from the old German V-2 missile.

Two types of superheavy self-propelled artillery pieces mounted on heavy tank chassis with gun calibers of about 12 in., and 30 ft in length. The shells for these guns could carry nuclear warheads and are indicative of the Soviet technological advance in the field of conventional weapons.

A successor to the heavy JS-3 tank with a more powerful 122-mm gun, improved engine, increased armor thickness, and increased cruising range.

Further changeover from wheeled to tracked vehicles shown in a tracked amphibious armored personnel carrier which carries 15 men and is armed with a 12.7 mm heavy machine gun.

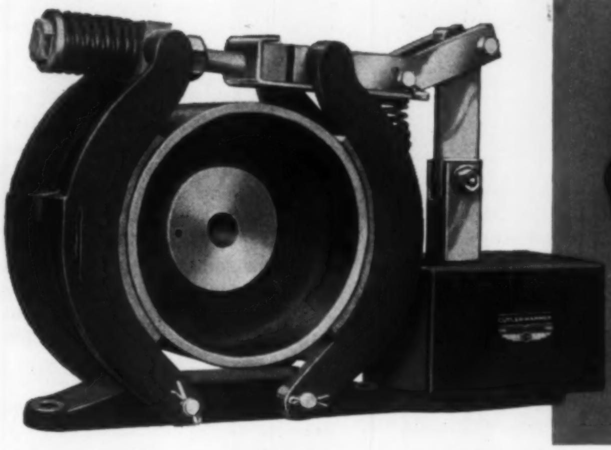
First appearance of a self-propelled twin 57 mm antiaircraft weapon which provides effective defense against aircraft from heights up to at least 10,000 feet. The

THREE good reasons why Cutler-Hammer 511 brakes are preferred throughout industry

OEM DESIGN ENGINEER— "We've tested them all and standardized on Cutler-Hammer 511 Brakes. They're easier to install and our customers seem well satisfied too."

PLANT MANAGER— "Our conveyor system came equipped with Cutler-Hammer Brakes and they haven't given us a bit of trouble since the system went into operation."

MECHANICAL MAINTENANCE MAN— "As part of my job I service the brakes on our cranes and not only are the C-H solenoid brakes easier to adjust, but they hold their adjustment longer than any we ever had."



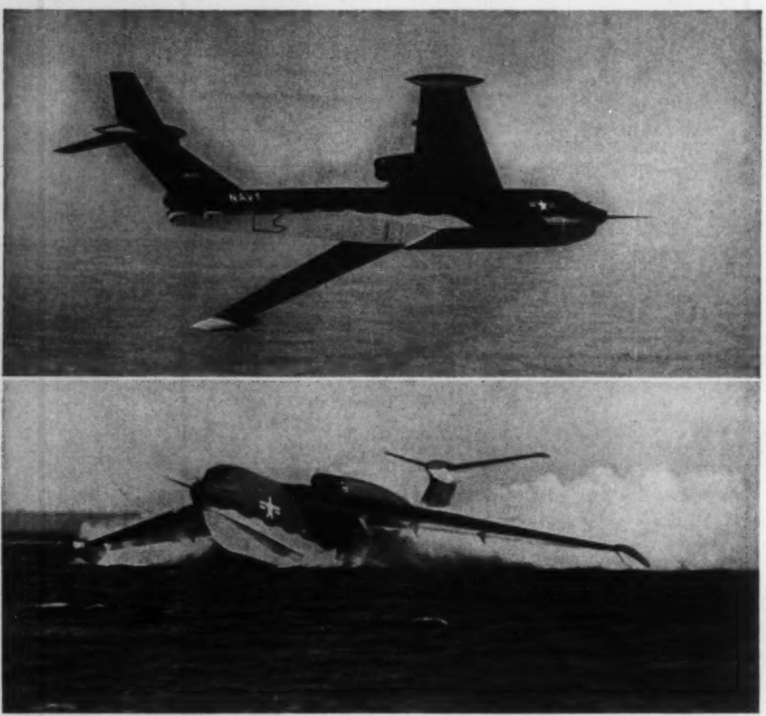
CUTLER-HAMMER
MOTOR CONTROL
C-H

You, too, will find it pays to specify and install Cutler-Hammer 511 Solenoid Brakes. Available for either A-c or D-c service, Cutler-Hammer 511 Solenoid Brakes are rated from 3 to 125 lbs. ft. torque continuous duty and 3 to 160 lbs. ft. torque intermittent duty. Write today for Bulletin 511 for complete description, ratings, optional features, and dimensions. CUTLER-HAMMER Inc., 1310 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer Ltd., Toronto.

Circle 407 on Page 19

twin 57 mm fills a long-standing gap in the Soviet armory—a weapon of high mobility for the protection of armed columns on the move.

The *Army Information Digest* concludes that "it is evident that no effort or expense has been spared to equip the Soviet ground forces with the most effective weapons and equipment of all types that modern techniques can provide. Great stress has been placed on both mobility and firepower and the modernization program has covered everything from pistols to . . . guided missiles."



EASY TO DISPERSE, the Navy's new P6M Martin jet seaplanes will act as high-speed minelayers or bombers in event of war. Plane can refuel from a submarine, deliver weapons on targets over a 2000-mi range. Four P & W J-75 engines mounted in dual wingtop nacelles give the P6M a top speed in excess of 600 mph. Cruise altitude is 40,000 ft; payload, 15 tons. In top picture, unique rotary mine door, which will carry a variety of weapons, is shown in hull center. Black outline on rear hull is set of hydroflaps used for water maneuverability. The big jet can negotiate 6-ft waves and can be serviced, including complete engine change, while afloat.

Precompressed Plastics Molding Claims Better Products, Less Cost

NEW YORK — Two manufacturers report unusual success with a new injection molding technique for plastics. Columbus Plastic Products Corp., inventor of the new "precompression" (valve gating) process, and W. R. Grace Co., sole license holder, predict that it will "revolutionize the molding of all thermoplastic materials." Grace has used the process in molding high-density polyethylene in a variety of products.

In normal injection molding, the molten material is allowed to ooze through an opening into the mold cavity. The new valve-gate technique holds the material in a reservoir, building up pressure that releases the valve and causes the material to gush into the cavity at high velocity. One of the advantages: multiple valve gating, which permits the molding of larger and deeper pieces with greater areas, using smaller machines.

Economy of operation in the new process results from reduced molding cycles, less scrap, and fewer rejects. Improved products are claimed through better physical properties and reduction in over-all shrinkage.

Topics

Information please will be a simplified request at the 1958 Design Engineering Show, thanks to an innovation by show managers Clapp & Poliak. Plastic name-and-address plates, similar to those used for department-store charge accounts, will be distributed in advance of the show and at the show. Booths will be equipped with machines to print the information on requests for literature or a visit from a salesman. Visitors desiring an inquiry plate should write before March 31 to Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y., giving full name, exact title, name of company, street address, city, zone, and state.

• • •

A noise that annoys a barnacle is being used to keep these animals off ships in Syndey, Australia. An electronic gadget sends supersonic waves through a ship's hull to repel barnacles, which are allergic to vibrations between 17 and 20 kcps.

• • •

Not since Eli Whitney has there been an essential change in cotton ginning methods. Now, a team of technologists at Battelle Memorial Institute, Columbus, Ohio, has been commissioned by the Dept. of Agriculture to search for improved methods. Howard C. Davis, head of the team, observes that "after 160 years, perhaps it is time for an organized search to discover if there are better ways to gin cotton." He also discloses that consideration will be given to the use of ultrasonic vibration or of nuclear radiation to aid in separating the seed from the cotton fiber.

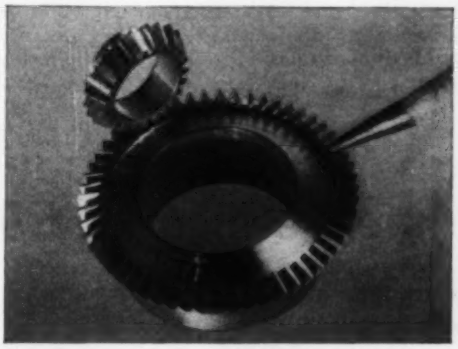
• • •

Plastic divining rod has proved superior to the old-fashioned twig. An Ohio dowser who has been successfully locating underground springs for more than 40 of his 71 years claims that his Y-shaped plastic stick is best because it cannot be affected by foreign substances.

• • •

First aluminum-girder bridge in the world will be constructed near Des Moines, Iowa, to carry traffic across a four-lane, interstate express highway. It will be a four-span continuous aluminum-girder structure with a composite reinforced concrete deck. It will be 222 ft long, 36 ft wide, with a 30-ft roadway, and will be supported by concrete piers.

CURVIC COUPLINGS provide an accurate, light, compact, and self-contained connection in which the teeth both center and drive. The Curvic design represents a new standard in the application of coupled parts.



BEVEL GEARS

When a gear or a coupling determines the *accuracy of trajectory*...

When a missile or rocket works on paper the best way to get it into the air is to see to it that all the parts agree with the paper work.

And when one of those parts is a bevel gear or coupling, Gleason engineers can help you three ways:

1. Engineering service. Our full staff of engineers is ready at all times to help you develop bevel gear combinations and Curvic® Coupling designs. They can help you make sure that either part meets your specifications.

2. Machines to cut or grind to your tolerances. You can produce any fine pitch gear—spiral bevel, hypoid, Zerol® or Coniflex®—precisely and economically with any of five Gleason machines.

No matter how rigid your specifications or the size of your parts, our engineers can help you select the right machine or combination of machines for 100% accuracy.

3. Complete testing equipment. We have engineered a series of testers for making certain that all parts do meet your critical specifications. For example, on the Gleason No. 104 Hypoid Tester you obtain a permanent test record to help you match pairs properly and to keep a graphic record of the rolling qualities, tooth spacing, and concentricity of your parts.

Any or all of these services are yours for the asking at any time.

GLEASON WORKS

Builders of bevel gear machinery for over 90 years

1000 UNIVERSITY AVE., ROCHESTER 3, N.Y.

71

Circle 408 on Page 19

BOEING
707
BOEING 707

The Boeing 707, America's first production jet transport, will be produced in four models to fit a variety of airline route requirements. Three engine choices and flexible interior arrangement can give the airline operator a highly versatile carrier. Fourteen world airlines have ordered more than 160 of the big jets, with first scheduled operations set for 1959. Flight time from Los Angeles to New York: 4hr, 12 min.

National Document Center Moves Closer to Reality

CLEVELAND—Creation of a national center for co-ordination of scientific and technical information is closer to reality following a recent conference at Western Reserve University. Recommendation of the 150 scientists and business leaders attending: A "crash" program to study the problems involved in establishment of the center should immediately be initiated.

Accordingly, the Council on Documentation Research will act on the recommendation of the WRU conference, and request that the National Academy of Sciences sponsor the study. This will give the plan the national recognition necessary to win approval and support of industry, government, academic institutions, and the foundations.

Scientists at the meeting were in complete agreement as to the need for urgent action. Dr. D. C. Gull of the National Academy of Sciences declared that recommendations of the Council of Documentation Research would be favorably received. Ben H. Weil of Esso Research and Engineering said, "A crash program is needed in order to complete the study and decide on the best program."

First American Commercial Jets To Enter Airline Service in '59

Boeing's Versatile 707 "Family" is Designed For 600-mph Intercontinental or Short-Haul Service

SEATTLE — Around the world in less than 40 hours flying time will be possible in 1959 when the "family" of Boeing jet transports goes into commercial operation.

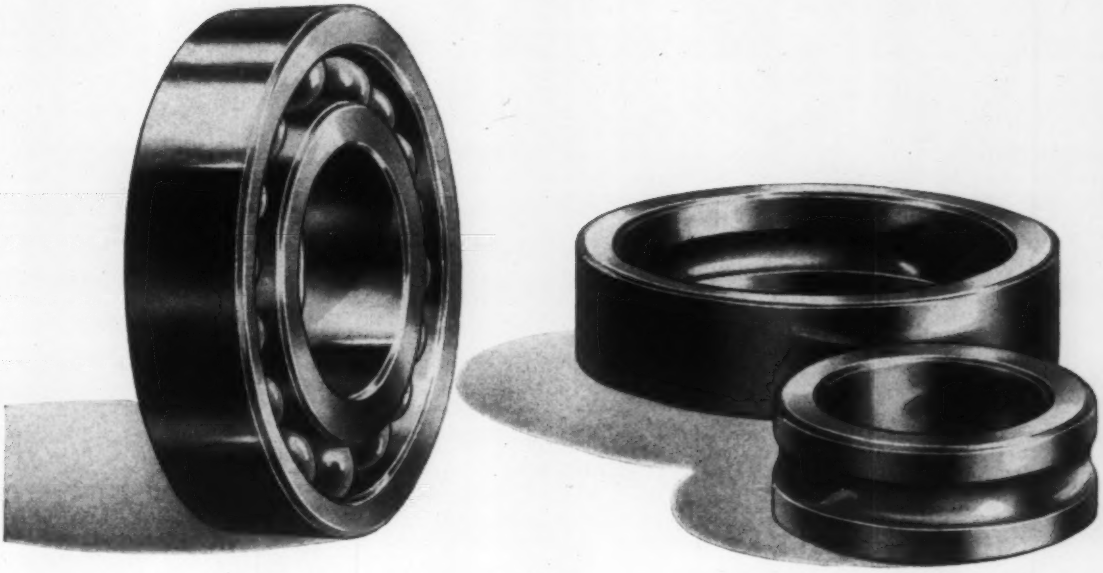
Built on two slightly different airframes, Boeing's new 707 models consist of the 707-120 and 707-220 Stratoliners, and the 707-320 and 707-420 Intercontinental models.

The 120 Stratoliner is the first and basic production jet transport. With a gross weight of more than 245,000 pounds, it is principally intended for continental use, although the plane is capable of full payload, over-ocean operation on many existing routes. Its four Pratt & Whitney JT3 turbojet engines provide a cruising speed of 591 mph. Deliveries of this model will start in 1958.

The 220 member of the family is identical in airframe and body size to the 120, but will be powered by the larger and more powerful Pratt & Whitney JT4 engines. Cruising speed will be 605 mph. Both the 120 and 220 will seat 124 in first class arrangement, 150 in tourist service.

The 320 and 420 are the Intercontinental 707s, and with this plane the dimensions change. It's the biggest member of the family, partially fulfilling the growth potential Boeing designed into the basic 707 series. Weighing more than 295,000 lb, it is 8 ft 5 in. longer overall than the 120 and 220, and has 11½ ft more wing span. Fuselage diameter, 148 in., is the same in all models. Difference between the 320 and the 420 is power plant, the 320 uses Pratt & Whitney JT4s, the 420 has Rolls-Royce Conways.

Cruising speed of the Intercontinental is 605 mph and it will fly at altitudes between 30,000 and 40,000 ft, well above the weather. Range with full payload and normal intercontinental fuel reserve will be more than 4500 miles, although the airplane will operate economically over distances as short as 500 miles, according to



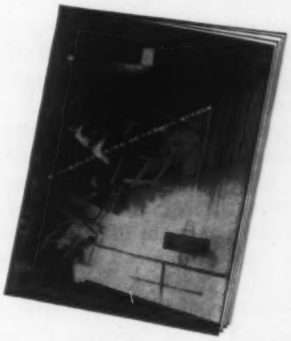
ARISTOLOY BEARING QUALITY STEELS MEET

EXACTING REQUIREMENTS OF BEARING MANUFACTURERS

Uniformity . . . minimum size and minimum frequency of non-metallic inclusions, freedom from segregation . . . these qualities are synonymous with the electric furnace process. They are also the prime requirement of bearing grade steels.

Here at Copperweld, careful selection of raw materials, precise melting in electric furnaces, and special care during teeming, produce Aristoloy—a steel which excels bearing grade steels made by any other method.

Available in 52100, 4620, 4720, 8620, and 4320, Aristoloy can be furnished in hot rolled or cold drawn, annealed (spheroidized annealed where required), rough turned, and turned, ground and polished. For assistance in selecting the best Aristoloy for your job, call or write. A qualified Copperweld Field Metallurgist will be glad to work with you.



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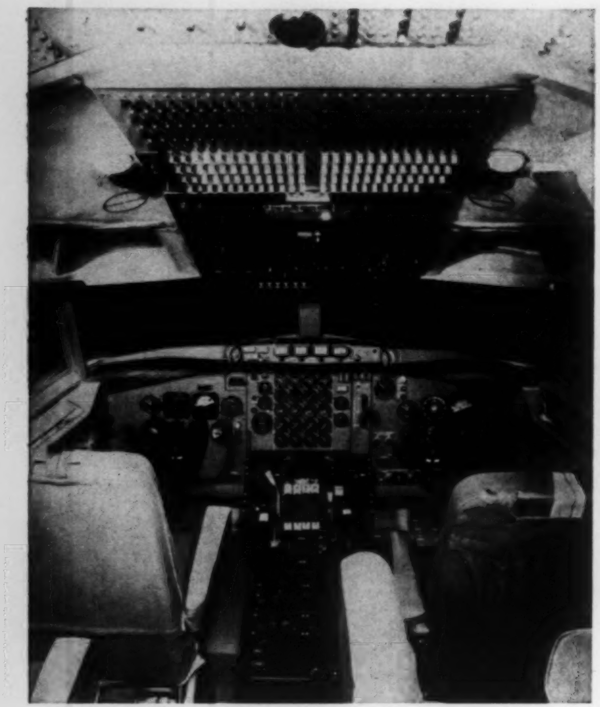
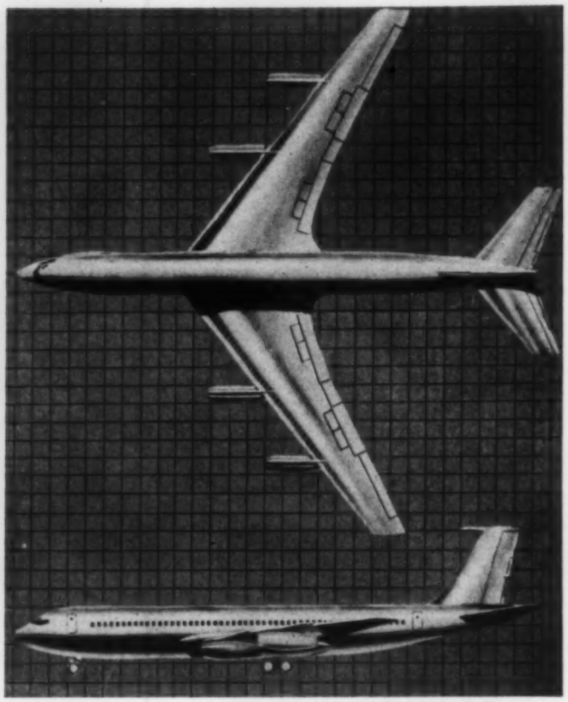
ARISTOLOY STEELS



Simplicity of the 707 cockpit has impressed the more than 150 airline pilots who have flown Boeing's prototype. The instrument panels mount 117 fewer instruments and indicators than are used on Boeing's piston-powered Stratocruiser. Gone are propeller pitch controls, feathering buttons, mixture controls, supercharger controls, and similar dials that indicate what goes on in the reciprocating engine and propeller.



Each square=5 ft, approx.

The family of 707's will differ in detail according to specifications of the operating airline, but will be basically similar. All will have 35-deg swept-back wings, with engines supported in four pods isolated from the primary structure of the airplane. Tandem mounting of engines was ruled out, since failure of one engine in a dual pod often results in damage to the other engine. Entrance doors are fore and aft.

Boeing. A total of 63 Intercontinentals have been ordered by various U. S. and foreign airlines.

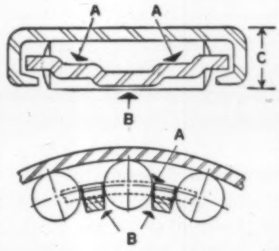
The entire 707 family will vary in passenger capacity according to the wishes of the operating airline. Seating for an Intercontinental standard day plane will be 131 first class, 162 tourist. One possible first-class version would provide three compartments—24 luxury, four-abreast seats in the forward area, convertible to 12 full-length berths; 20 reclining seats, five abreast, and spaced 60 in. apart in the central cabin, and 78 seats in the after cabin arranged six abreast on the same spacing as the luxury space forward.

As 707 deliveries begin, passengers and airlines will benefit by the considerable flight experience of the prototype, which had logged more than 700 hours flight time by early 1957, and by the large number of KC-135 U. S. Air Force jet multipurpose tanker transports which saw extensive service in 1957.

COMPUTER WITH A STEERING WHEEL enables GM research engineers to study car stability and control without venturing from the laboratory. The objective: to determine lateral motions of a car—yawing, rolling, or sideslipping—that result from steering wheel "input" applied by the driver. These motions depend upon the car's speed, wheelbase, steering gear ratio, tire properties, and suspension geometry. Equations relating to these variables have been developed, and the computer continuously solves the equations while permitting changes to be made in all of the car and tire characteristics. Miniature car on the simulator device provides an immediate visual idea of how a full-size automobile would respond to its wheel at 30 to 100 mph.

TORRINGTON

Features of the new
TORRINGTON DRAWN CUP ROLLER BEARING



- rollers end-guided at pitch line (A)
- shaft-riding retainer (B) designed to permit lubricant circulation
- high capacity in small cross section (C)
- long pregreased life
- efficient at high speeds
- mounted by press fit
- simple housing design
- low unit cost

INTRODUCING

a new low-cost precision roller bearing...

THE TORRINGTON DRAWN CUP ROLLER BEARING

For the first time, the advantages of drawn cup outer race construction are available in a precision roller bearing.

This compact, lightweight bearing consists of spherical end needle rollers, a one-piece hardened steel retainer and case-hardened thin-section outer race. Designed to run on a hardened shaft or with an inner race, this new series takes a press fit in a simple housing without snap-rings or shoulders.

Highly efficient roller guidance and lubrication are outstanding features. The shaft-riding retainer contacts the roller ends at the pitch line where guidance can be obtained with the least effort. The design provides ample storage for lubricant and promotes its circulation.

These features make the new bearing particularly suited to applications requiring compactness with precision, high-speed endurance or long pregreased life.

For information on sizes now available and for application assistance, call on our Engineering Department or write for the new bulletin, "Torrington Drawn Cup Roller Bearings." THE TORRINGTON COMPANY, Torrington, Conn. — and South Bend, Ind.

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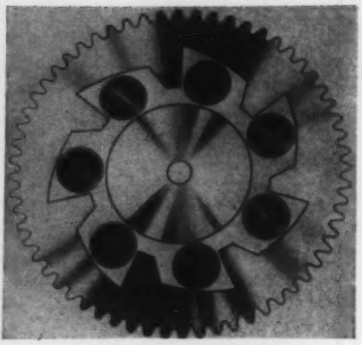
Two Clutches Couple Self-Winding Mechanism

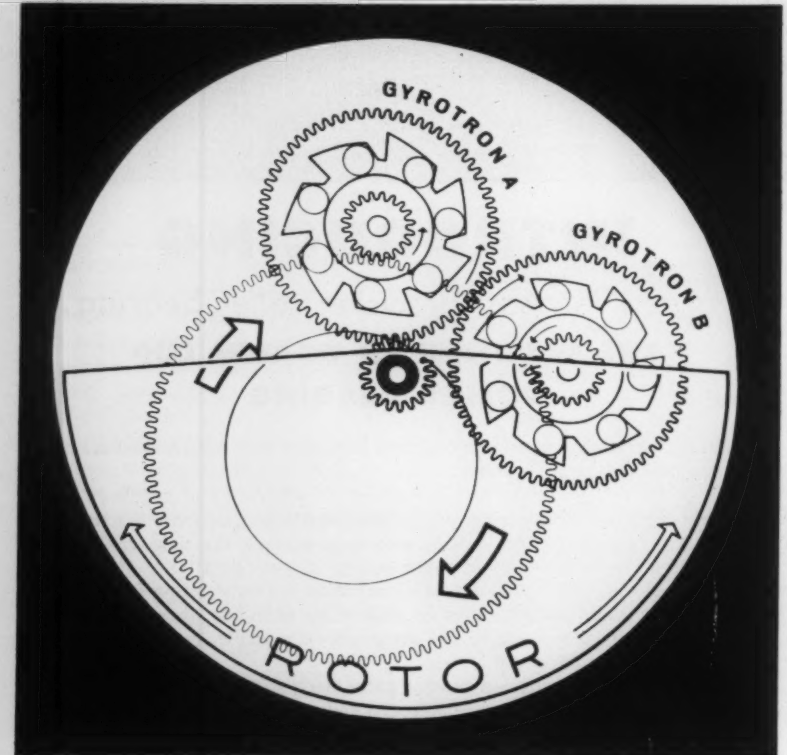
New York — A simple energy transfer device winds the mainspring in a new automatic watch. Girard Perregaux & Co. in their new Gyromatic 39 watch, use two clutches to convert the motion of a swinging weight into a unidirectional rotation.

The clutch system results in a self-winding mechanism which reportedly will operate more efficiently than conventional systems. The clutches used in the new watch are called Gyrotrons A and B.

When the swinging weight inside the watch turns clockwise, Gyrotron A engages and partly winds the mainspring barrel while Gyrotron B slips. Alternately, when the swinging weight turns counterclockwise, Gyrotron A slips and Gyrotron B winds the barrel.



Clever clutch, key to new self-winding watch, features seven jeweled rollers as sprags. Ring gear, when driven counterclockwise, forces each roller to seat in narrowest part of notch; rollers force disc to turn with ring gear. Disc is connected through arbor to output pinion (not shown). When ring gear is driven clockwise, each roller seats in widest part of notch; disc rides free of ring gear. Long life is claimed for the clutch self-winder.



Self-winding mechanism uses clutches instead of pawls, ratchets, and springs to wind mainspring in single direction. In Girard Perregaux automatic watch, "rotor" swings back and forth. When rotor swings in clockwise direction, its pinion drives clutch, called Gyrotron A, counterclockwise. Clutch pinion drives mainspring gear clockwise. Gyrotron A ring gear also drives Gyrotron B ring gear, which slips free. When rotor swings counterclockwise, however, Gyrotron A ring gear slips free of rollers, while Gyrotron B ring gear, now rotating counterclockwise, drives mainspring gear.

Engineer Watches Colleagues' Salaries, Study Shows

Report Job Attractions Vary With Engineers' Functions

New York — Actual dollar-and-cents income is not the key factor to the typical engineer, a recent survey shows. More important is the feeling that his salary is as much or more than that paid other engineers on his own level. Prime inducements are interesting work and opportunities for advancement. Not so vital are company location, regular salary increases, and job security.

Why does an engineer choose working for one firm instead of another, stay with a firm or leave, work as hard as he can or take it easy? Some answers to these questions are found in *Motivating Factors in Engineer Employment*, a just-published three-part study, conducted by Deutsch and Shea Inc.

The study was designed to help companies improve their practices as engineer employers and also their utilization of engineers. It discloses which job elements fit into the engineer's psychological needs, values, and aspirations.

Engineers' satisfactions were found to vary according to their functions. Research and development engineers, for example, ranked especially high the opportunity to keep up with new developments in their fields, while administrative engineers aspired most to status and taking on ever-increased responsibilities.

The research and development engineer also sought work in which he could exercise most personal scope, work that is creative and challenging, the stimulation and challenge of complex problems, and credit for his ideas.

Design and product engineers were found to share many of the job aspirations of their colleagues in research and development, but have several that tend to be found most frequently in their own group. For example, they place considerable emphasis on proper programming and scheduling of work assignments, and on clear objectives and detailed planning. They want a planned program of opportunity for self-development and advancement. Unlike many research and development engineers, they prefer to "follow through" on the job they started. They tend to become considerably upset by delays or inadequate equipment and want reasons carefully explained. They put greater emphasis than the typical research and development man on compensation and economic advancement.

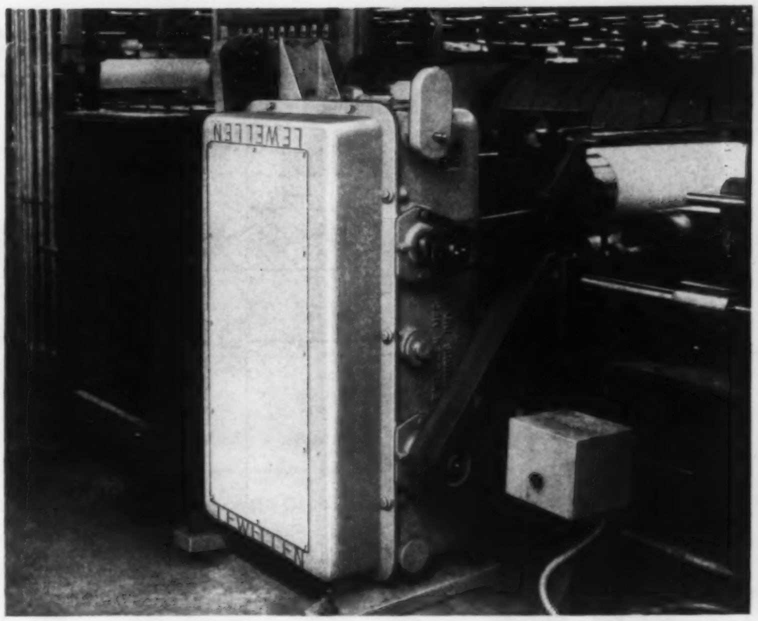
Not surprisingly, the sales engineer puts great emphasis on recognition and the feeling that he is doing highly important work is crucial to him. The social dimensions of his job are as important to him as the work and career dimensions. He wants to be part of management and have more than a nodding acquaintance with important top management people.

Giant Radio Transmitter Aligns Minitrack Stations

FORT MONMOUTH, N. J. — A giant new radio transmitter has bounced signals from the moon to insure close tracking of the Army's Explorer and other U. S. satellites which may be projected. The calibration tests, conducted by the U. S. Army Signal Corps, assured that Minitrack listening posts throughout the Western Hemisphere and on the West Coast of Africa would be tuned to precisely the same frequency. The tests were used also to check the internal computing systems of the Minitrack stations.

By use of a highly directional antenna, the transmitter power was packed into a narrow beam equal to a million and a half watts. Operating on a frequency of 108 mc, the transmitter permitted alignment of all tracking receivers, requisite to accurate measurement of the Doppler shift in radio frequency. The Doppler effect is used for computing satellite speed and direction.

Man-made hailstorm has been used to test the Convair 880 jet transport. Its wing leading edge section was blasted with 1¼-in. diam hailstones propelled at 575 mph. The hailstone tests are believed to be the first in jet transport development.



MATCH the SPEED to the OPERATION...AUTOMATICALLY

LEWELLEN
V/S TRANSMISSIONS

Machine motions, which reflect the operation, may be coupled with Lewellen Controllers to provide precisely the speeds the operation demands. For example—

This Champlain Laminator and Four-Color Press installation at the Alton Boxmakers mill.

Lewellen V/S Transmission drives Laminator at speeds that synchronize with Press, at constant web tension. Lewellen Controller couples to floating roll between machines.

Measuring ratios of machine motions will obtain proportionate speeds—or—measuring rates of motions will maintain these rates, whatever the speeds required.

Lewellen V/S Transmissions and Controllers provide stable, continuous operation automatically, by translating machine motions into correct speeds, at the right moment.

WRITE FOR CATALOG 65

SPEED CONTROL

LEWELLEN MANUFACTURING CO., COLUMBUS, IND.
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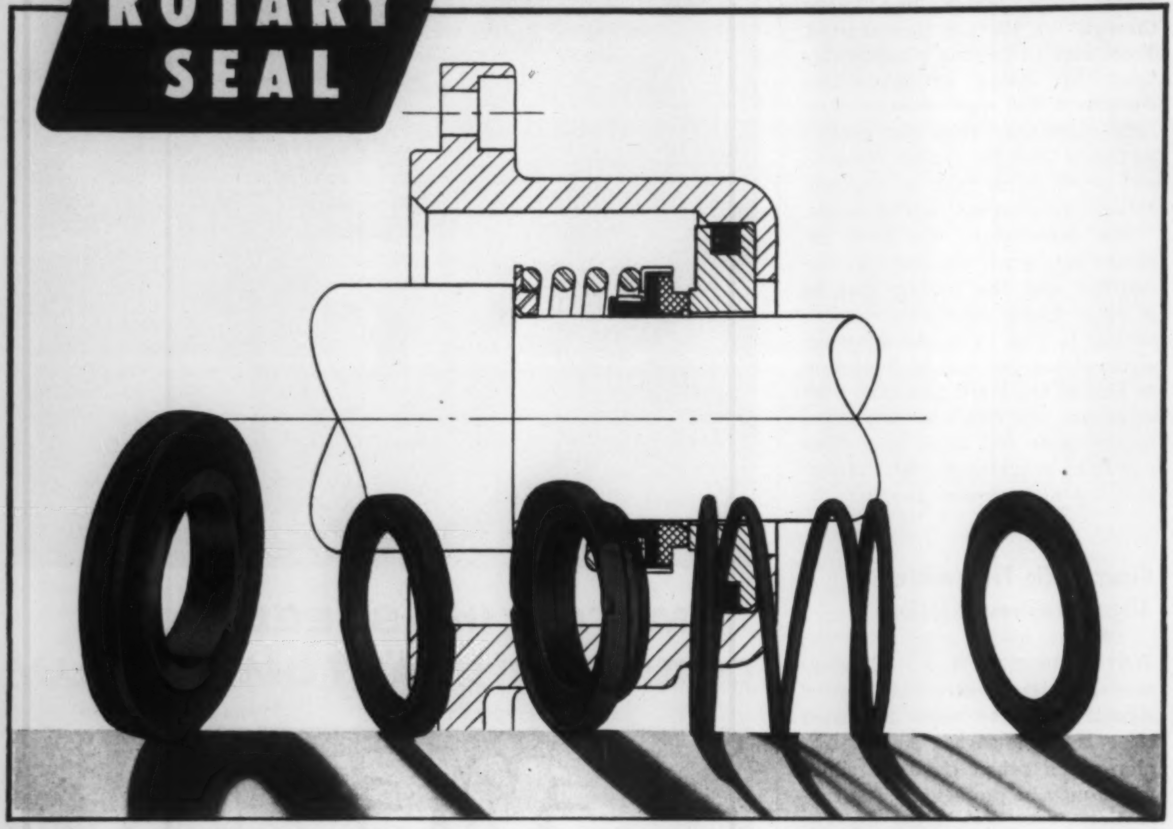
Circle 411 on Page 19

ROTARY SEAL SPECIALIZED SEAL ENGINEERING



is developing new ways to assure top performance in COMMERCIAL AIR CONDITIONING EQUIPMENT

The operating conditions of a heavy-duty commercial air conditioning compressor unit are tough for ordinary Shaft Seals to handle. The combination of high operating speed and pressure is conducive to high heat generation—and that, in turn, can lead to Seal failure and unit breakdown.

The sound design of ROTARY SEALS—properly adapted to the particular conditions of this application—removes most of the major cause of such failures, without requiring complicated unit design. With this sturdy Seal, heat dissipation is excellent, and even under the severe operating conditions, heat generation is effectively reduced. Net result: greater customer satisfaction, elimination of trouble and expense through constant service calls.

The ROTARY SEAL illustrated was specially developed to meet this exact requirement. You can't just reach back on the shelf for a Shaft Seal when your compressor—or pump, tractor or whatever your unit may be—must measure up to unusual or especially taxing job requirements. It takes a *custom-designed* Seal—fitted in every detail to the specific job at hand.

ROTARY SEAL specializes in developing and manufacturing Seals to meet such problems, by applying the basic ROTARY SEAL principles which opened the way to successful mechanical Shaft Sealing when this company introduced them years ago.

The best time to start solving your Shaft-Sealing problem is at the drawing-board stage. Call in our engineers for an early consultation—our experience with Seal applications of all kinds in many fields often indicates suggestions which can simplify design, lower costs and improve performance.

Shaft-Sealing with Certainty

mechanical seals for ROTARY SEALS rotating shafts

ROTARY SEAL DIVISION
MUSKEGON PISTON RING CO., SPARTA, MICHIGAN

Circle 412 on Page 19

Reader Information Service

SUBJECT INDEX

Editorial and Advertising content classified by subject and listed by page number for convenience when studying specific design problems. For further information on subjects advertised, refer to advertisement and circle Item Number on a Yellow Card—following page.

Actuators, Edit. 252; Adv. 63
Adhesives, Edit. 227, 235; Adv. 208
Airplanes, jet, commercial, Edit. 10
Aluminum and alloys, Adv. 85
Armature winding, dc, Edit. 184

Balls, Adv. 40
Bearings, ball, Edit. 212; Adv. inside front cover, 21, 68
  needle, Adv. 21, 249
  rod-end, Adv. 260
  roller, Adv. 13, 21, 68, back cover
  sleeve, Adv. 204, 260
  thrust, Adv. 124
Belts, conveyor, Adv. 218
  transmission, Adv. 88, 92, 96
Blowers, Edit. 224; Adv. 86
Bobbin cores, magnetic, Edit. 215
Books, Edit. 243
Booster, power-steering, Edit. 254
Brakes, Adv. 7, 108, 200
Brass (see Copper and alloys)
Bronze (see Copper and alloys)
Bushings, Edit. 228; Adv. 204

Cabin top, retractable, for boat, Edit. 162
Cams, Edit. 136
Caps, Adv. 121
Carbon and graphite parts, Adv. 252
Castings, centrifugal, Adv. 119
  die, Edit. 159; Adv. 122, 236
  investment, Adv. 244
  nonferrous, Adv. 119
  steel, Adv. 48
Chain, conveyor, Adv. 41, 216, 232
  transmission, Adv. 41, 92, 216, 232, 261
Circuit breakers, Edit. 232
Clamps, Adv. 222
Classified ads, Adv. 266
Clutches, Edit. 14, 202, 250, 256; Adv. 108, 114, 200, 224, 263
Coatings, protective, Edit. 44, 232
Cold heading, Adv. 261
Compressors, Edit. 135, 137
Computations, graphical, Edit. 163
Computers, Edit. 36
Connectors, electric, Edit. 202, 206, 212, 227
Contactors, Adv. 194
Control systems, electric, Edit. 136; Adv. 112, 123
Controls, automatic, Edit. 223; Adv. 15, 212
  electric, Adv. 71, 260
  hydraulic, Adv. 70, 240
  liquid-level, Adv. 262
Corrosion-resistant alloys, Adv. 201
Counters, Edit. 218, 222; Adv. 221
Couplings, shaft, Edit. 222, 250; Adv. 9, 25, 38, 187, 238
Cylinders, Edit. 224; Adv. 39
  hydraulic, Adv. 110

Dampers, pulsation, hydraulic, Edit. 254
Diagrams, network, Edit. 163
Diaphragms, Adv. 102
Differentials, gear, Edit. 36
Domestic machines, Edit. 159
Drafting efficiency, increasing, Edit. 26
Drafting equipment, Edit. 26, 238; Adv. 91, 104, 115, 215, 250, 266
Drives, adjustable speed, Edit. 233; Adv. 45, 108, 118, 123, 210, 226
Duct, flexible, Adv. 266
Dynamometers, Adv. 108

Electric equipment (see specific type)
Engineering, professional, Edit. 147
Engineering department (see Management or Drafting)
Engines, Adv. 94, 116, 261

Facilities, general, Adv. 64
Fasteners, Adv. 66
  blind, Adv. 234
  bolts, nuts, screws, Edit. 230; Adv. 37. 52, 84, 113, 197, 206, 228, 257, 259, 261
  insert, Adv. 264
  locking, Adv. 241
  pin, Edit. 215; Adv. 262
  retaining rings, Edit. 202; Adv. 69
  rivet, Adv. 234, 251
Felt, Adv. 233
Fiber, Adv. 225
Filters, Adv. 100
Finishes (see Coatings)
Fittings, pipe, tube and hose, Edit. 226, 235; Adv. 59, 81, 126, 198, 257
Friction materials, Adv. 217, 231
Fuels, unburned, Edit. 33

Gages, pressure, etc., (see Instruments)
Gaskets, Adv. 42
Gear shaping, Adv. 9
Gear trains, precision, Edit. 156
Gears, Adv. 50, 185, 187, 220, 243, 258, 263
Generators, electric, Edit. 226
Glass, Adv. 258

Handles, Adv. 263
Heaters, Adv. 210, 244, 259
Hose, nonmetallic, Adv. 102
Hydraulic equipment (see specific type)

Instruments, Edit. 160, 238; Adv. 220, 254
Insulation, Adv. 203, 225
Inverters, static, Adv. 223

Latches, Adv. 76
Levers, Adv. 263
Lighting, Edit. 214
Lubrication equipment, Edit. 231; Adv. 62, 79

Machines (see specific type)
Management, engineering, Edit. 14, 29, 30, 128
Meetings, Edit. 44; Adv. 199
Metals (see specific type)
Models, structural-test, Edit. 175
Motor bases, Edit. 233
Motors, electric:
  brakemotors, Adv. 255
  fractional and integral hp, Edit. 216, 223; Adv. 1, 77, 82, 97, 106, 125, 204, 255, 258
  gearmotors, Adv. 53, 185, 207, inside back cover
  subfractional hp, Edit. 210; Adv. 189
Motors, pneumatic, Adv. 80
  synchronous, starting, Edit. 138
Mountings, vibration and shock, Adv. 253

Nickel and alloys, Adv. 191

Packings, Edit. 202; Adv. 2, 87, 103, 217
Panels, steel-foil corrugated, Edit. 179
Plastic parts, thin-wall, Edit. 171
Plastics, Adv. 87, 102, 203, 205, 230
Plastics molding, Edit. 8
Plugs, Adv. 121

MACHINE DESIGN is indexed in Industrial Arts and Engineering Index Service, both available in libraries, generally

SUBJECT INDEX (continued)

Pneumatic equipment (see specific type)
Potentiometers, Edit. 219
Powder metallurgy, Adv. 98
Pulleys (see also Sheaves), Edit. 250
Pumps, Edit. 39; Adv. 183, 219, 259
  hydraulic, Edit. 219; Adv. 90
  pneumatic, Adv. 239
Punching, Adv. 28

Reducers, speed, Adv. 53, 185, 220
Regulators, pressure, Edit. 228
Relays, Edit. 218, 233; Adv. 46, 71, 257, 262, 266
Reports, research, Edit. 29
Research and development, Edit. 128
Resistors, Adv. 51
Rheostats, Adv. 51
Rollers, rubber, Adv. 265
Rubber, Edit. 214, 220, 226; Adv. 42, 102, 111, 245

Screws, power, Adv. 63
Seals, Edit. 202; Adv. 42, 87, 117, 192, 217
  mechanical, Edit. 216; Adv. 16, 42, 192, 212
Servo transient response, Edit. 148
Servos, Edit. 204; Adv. 35, 70, 210, 265
Sheaves (see also Pulleys), Adv. 60
Silicones, Edit. 220
Splines, ball-bearing, Adv. 63
Springs, Adv. 265
Sprockets, Adv. 41, 92, 216, 232, 261
Starters, engine, Edit. 134; Adv. 61
  motor, Adv. 71, 112, 246
Steel, Adv. 11, 64, 193
  stainless, Adv. 269
Steering, power, Adv. 204
Switches, Edit. 208, 223, 227; Adv. 212, 260
Swivel joints, Edit. 208
Systems, hydraulic, Edit. 252

Terminals, Adv. 196
Testing, Edit. 175; Adv. 9, 190, 260
Thermocouples, Edit. 210
Thermostats, Edit. 230; Adv. 120
Timers, Adv. 189, 266
Tips and techniques, Edit. 146, 158
Titanium and alloys, Adv. 237
Torque converters, Adv. 242
Transducers, Adv. 220
Transistors, Edit. 236
Transmissions, adjustable speed, Edit. 220; Adv. 15, 105, 108, 118
Triode tubes, Edit. 236
Truck styling, Edit. 22
Tubing, Adv. 5, 67, 101, 211, 213, 229, 235

Universal joints, Edit. 256; Adv. 270

Valves, Edit, 208, 228, 231; Adv. 107, 195, 262
  hydraulic, Adv. 70, 240
  pneumatic, Adv. 214, 256

Ways, machine, Adv. 95
Wear plates, Adv. 95
Wear-resistant alloys, Adv. 78, 201
Welding, Adv. 74
Weldments, Adv. 64
  high-strength steel, Edit. 181
Wire and wire products, Edit. 202
Wood, Adv. 44

USE A YELLOW CARD
for More Information . . .

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

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Index to New Parts & Helpful Literature
BY ITEM NUMBERS

HELPFUL LITERATURE—*descriptions start on page 188*

	ITEM NUMBER		ITEM NUMBER
Diaphragm Seals	601	Plug-in Limit Switch	632
Pigtail Splicing	602	Hydraulic Packings	633
Lubrication Equipment	603	Relief Valves	634
Rotary Compressors	604	Alloy Temperature Ranges	635
Brazing Material	605	Large Induction Motor	636
Steel Bars	606	Vacuum Breaker	637
Magnetism in Steels	607	Filters & Capacitors	638
Drives & Conveyors	608	Drafting Tables	639
Fuse Products	609	Ductile Iron	640
Panel & Flashlight Lamps	610	Fasteners	641
Miniature Couplings	611	Vibrationproof Switch	642
Multiple Circuit Switch	612	High Strength Bolts	643
Molded Plastic Parts	613	Data Logger	644
Motors	614	High Fidelity Cabinets	645
Tubing	615	Vibration & Shock Control	646
Centralized Lubrication	616	Vacuum Metallizing	647
Packings	617	Systems Manufacturing	648
Exchangers	618	Plastic Blower Wheel	649
Motors	619	Switch Terminology	650
Threaded Tubular Rivets	620	Nickel-Chromium Castings	651
Special Motors	621	Counting Devices	652
Conveyor Chain & Sprockets	622	Flow Meters	653
Solid Film Lubricant	623	Four-way Hydraulic Valves	654
Rectifier Stacks	624	Electronic Comparator	655
Ball Bearing Yield	625	Variable Speed Drives	656
Roller Chains	626	Flow Meters	657
Electric Motors	627	Temperature Control	658
Printed Circuit Receptacle	628	Drill Jig Bushings	659
Lubricant System	629	Stabilized Amplifier	660
Plastic Extrusions	630	Power Resistor Decade Box	661
Shaft Retention Fasteners	631		

NEW PARTS & ENGINEERING EQUIPMENT—*descriptions start on page 202*

	ITEM NUMBER		ITEM NUMBER
Indexing Clutch	662	Pressure Switches	693
Retaining Ring	663	Blower Wheels	694
Printed-Circuit Receptacle	664	Cylinders	695
O and V-Ring Seals	665	Synthetic Rubber	696
Miniature Insulated Wire	666	Generators	697
DC Servomechanisms	667	Fitting	698
Fan Motor	668	Silicone-Rubber Adhesive	699
Splicing Connector	669	Toggle Switches	700
Miniature Connectors	670	Miniature Power Connectors	701
Manual Shut-Off Valve	671	Pressure-Reducing Valves	702
Rotary Switch	672	Universal Joint Bushing	703
Ball Joint	673	Temperature Control	704
Universal Thermocouples	674	Standard Bolts	705
Permanent-Magnet Motor	675	Oil-Level Indicator	706
Teflon Tube Socket	676	Metering Valves	707
Ball Bearings	677	Air Circuit Breakers	708
Nitrile Rubber	678	Varnish	709
Indicator Lights	679	Hermetically Sealed Relay	710
Magnetic Bobbin Cores	680	Remote-Control Base	711
Spring Pins	681	Reusable Fitting	712
Motors	682	Film Adhesive	713
Rotary Face Seal	683	Subminiature Twin Triode	714
Small Stroke Counter	684	Transistor	715
Meter-Relay	685	Template	716
Hydraulic Pumps	686	Miniature Accelerometer	717
Subminiature Potentiometers	687	Plastic Scale	718
Variable-Pitch Pulley	688	Multiverter	719
Silicone-Rubber Compounds	689	Drawing Board	720
Add-Subtract Counter	690	Drafting Pen	721
Coupling	691	Slip-Ring Assemblies	722
Electric Motors	692		

MACHINE DESIGN
FEB. 20, 1958

Circle item number for information on products advertised or described or copies of literature.

401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
408	433	458	483	508	533	558	583	608	633	658	683	708	733	758
409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
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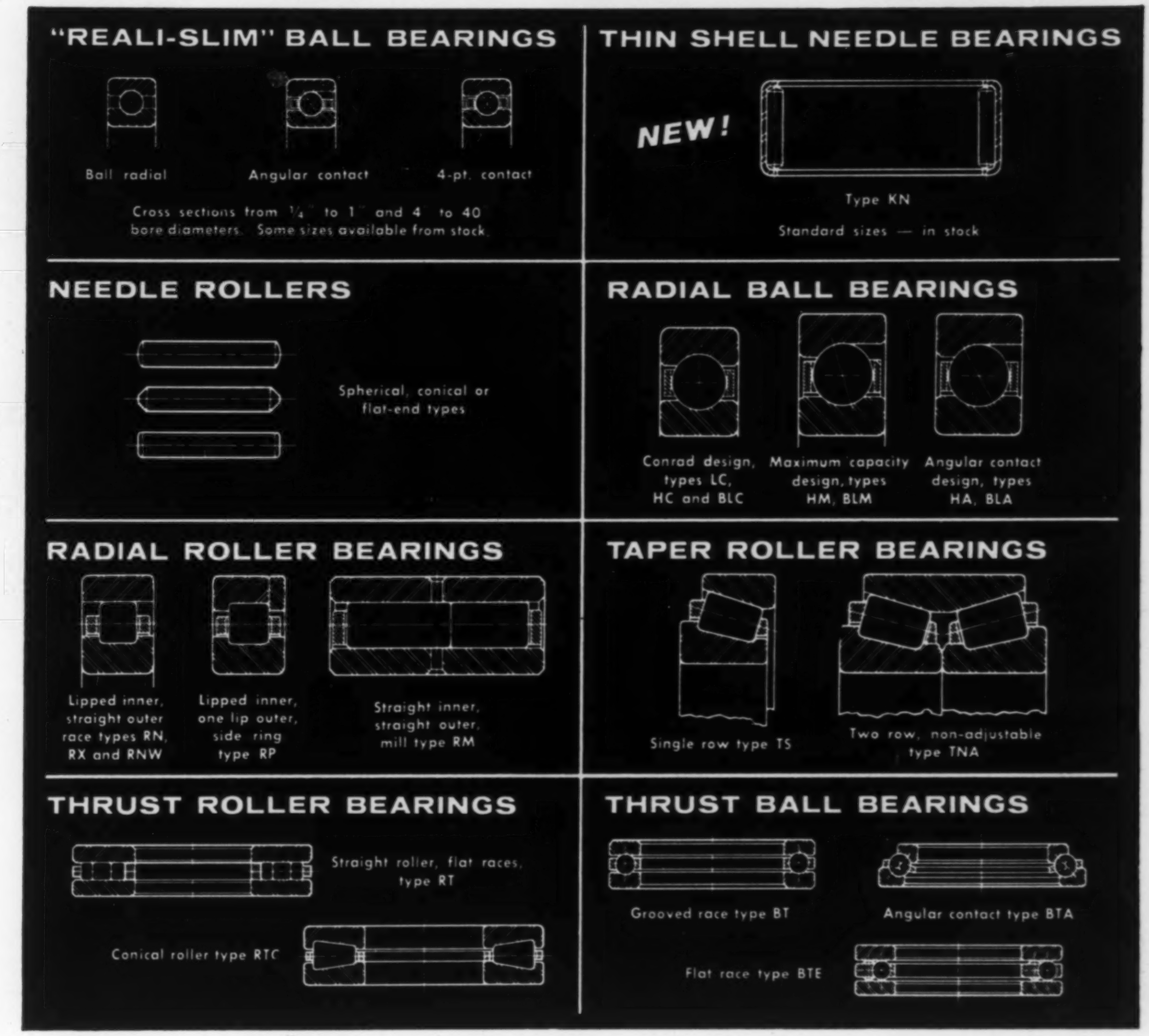
EXTRAORDINARY BEARING PROBLEMS?



"REALI-SLIM" BALL BEARINGS

Ball radial

Angular contact

4-pt. contact

Cross sections from ¼" to 1" and 4" to 40" bore diameters. Some sizes available from stock.

THIN SHELL NEEDLE BEARINGS

NEW!

Type KN

Standard sizes — in stock

NEEDLE ROLLERS

Spherical, conical or flat-end types

RADIAL BALL BEARINGS

Conrad design, types LC, HC and BLC

Maximum capacity design, types HM, BLM

Angular contact design, types HA, BLA

RADIAL ROLLER BEARINGS

Lipped inner, straight outer race types RN, RX and RNW

Lipped inner, one lip outer, side ring type RP

Straight inner, straight outer, mill type RM

TAPER ROLLER BEARINGS

Single row type TS

Two row, non-adjustable type TNA

THRUST ROLLER BEARINGS

Straight roller, flat races, type RT

Conical roller type RTC

THRUST BALL BEARINGS

Grooved race type BT

Angular contact type BTA

Flat race type BTE

ECONOMICALLY SOLVED AT KAYDON

When bearing problems seem next to impossible — when design considerations appear insurmountable — it's time to call KAYDON.

You'll find KAYDON'S full-time, experienced bearing-design engineers can take your problem in hand — and take worries off your mind. Their record is one of remarkable success — designing and producing bearings others said "couldn't be made."

Extraordinary bearing problems are KAYDON'S daily assignment. The tougher the better! If your designs require bearings of exceptional thrust or radial capacity, close-tolerance precision and/or "*Reali-Slim*" section, or extra-large diameter bearings up to 130" O. D., call or write KAYDON for specific recommendations, economical solutions. You'll be glad you did.

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All types of ball and roller bearings — 4" bore to 130" outside diameter . . .

Taper Roller • Roller Thrust • Roller Radial • Bi-Angular Roller • Needle Roller • Ball Radial • Ball Thrust Bearings

Circle 413 on Page 19

GEORGE W. WALKER, director of styling, Ford.

"American trucks, once considered country cousins of the more glamorous passenger cars, now have become sophisticated enough to be at ease on a boulevard as well as a country lane. Glamour has been added, and styling has been responsible for the addition."

VIRGIL M. EXNER, director of styling, Chrysler.

"A different approach is taken for truck styling from that used for passenger cars. In passenger cars we strive for a light, airy look. In trucks we deliberately create a rugged appearance . . . we try to combine the conveniences and attractiveness of a passenger car with the necessary functional requisites of a truck."

TRUCKS: THE STYLISH

POUND FOR POUND, the styling race in pleasure cars is barely keeping even with dramatic changes being made in truck appearance. In spite of the engineering facts of life, truck stylists have overhauled their styling concepts, and come up with a remarkable selection of vehicles, all "styled to the job."

Fast - changing passenger car styling has provided some valuable and well-proved styling features. Ford's George Walker notes, "One of the first big milestones in glamourizing trucks was the use of the curved windshield, as uneventful as it may seem now. This was followed by the full-wrap windshield and the wrap-around backlight, both of which were further successful attempts to apply some of the glamour of passenger car styling to the design of trucks. While these innovations were introduced principally to provide better vision, they also gave truck stylists a fine opportunity to enhance the appearance of their products and achieve a modern look.

"Next came the lower over-all height and enclosed running boards. These features, coupled with an increased cab width that made it possible to flush the cab door surface with the fenders, provided what was perhaps the biggest single opportunity for styling advancement."

On the mechanical front, engine accessibility is of paramount importance for maintenance purposes. To achieve this objective, a whole new front-end organization with full-width hood has become fairly universal. This further simplifies sheet metal contours by doing away with the raised center portion of the hood which formerly defined the engine compartment.

BOUNCE SPACE IN THE DRIVER'S SEAT

Outspoken truck drivers, alert managers, and research - minded stylists have combined forces to completely revamp truck cabs.

"At Chrysler," says Virgil Exner, "We place increased emphasis on cab conveniences and driver comforts in order to reduce driver fatigue and create a more pleasant psychological atmosphere. We have made entrance and exit to the cab easier for the driver, installed pushbutton controls and power accessories, offered ceiling-mounted transistor radios, designed a handsome, yet comfortable seat. We have placed more stress on headroom, because truck drivers are subjected to rough terrain and literally need headroom in which to bounce."

Other manufacturers and stylists are similarly impressed with styling from the driver's standpoint.

"Interior treatment offers one of the most exciting examples of the progress made in truck styling in recent years," according to George Walker. "Not too long ago, a drab, dark vinyl seat, usually dull brown or dark green, was the popular conception of what a truck interior had to look like. The only concern seemed to be that it should not show soil.

E. J. PREMO, assistant chief engineer, Chevrolet.

"Truck styling in recent years has taken on added meaning. With the greatly increased use of trucks, owners are becoming more and more style conscious. Whereas trucks at one time may have been purchased solely on the merits of their payload carrying ability since they were all plain 'work horses', today the owner looks to pleasing over-all lines and eye catching appeal of the vehicle to advertise his products or his services."

THEODORE ORNAS, chief engineer, styling section, International Harvester, Motor Truck Div.

"What should a truck look like? In the final analysis, it is the truck customer who decides . . . and the same kind of attention that is given to the styling of a pleasure car must be given to the motor truck if we are to meet the desires of this buyer who has been accustomed to the best in styling and appearance in everything he buys."

STOUTS

Emphasis on style is relatively new in the truck industry. How should a truck look? We asked four experts, and here's the answer.

"In 1953, still largely concerned with interiors that had a clean look, Ford introduced its new 'Driverized Cab' . . . and came forth with a gray and red all-vinyl seat. By 1955, this red and gray combination had evolved into a much brighter red and gray. Saran woven fabrics were used to add to the driver's comfort and to the eye appeal of the interior.

"This style improvement and brightening of interiors has greatly added to the comfort, convenience and security of the driver—factors that contribute to the safety of operation by lessening fatigue."

"The truck driver today no longer fits the popular conception of yesterday's driver," says International Harvester stylist Theodore Ornas. "Off duty, he probably drives a late model passenger car purchased, to some extent, on its styling merit. He is accustomed to plush interiors, power brakes, power steering, effortless shifting and all the other conveniences that stylists and designers can provide. The motor truck owner can no longer overlook this factor if he is determined to have qualified drivers to operate his fleet.

"While performance and utility may seem to dominate the buyer's thinking when it comes to purchasing a motor truck, he is still either consciously or unconsciously influenced by a good looking product with organized interior treatment, comfortable seating, easy steering, reduced noise, good ventilation, and increased visibility."

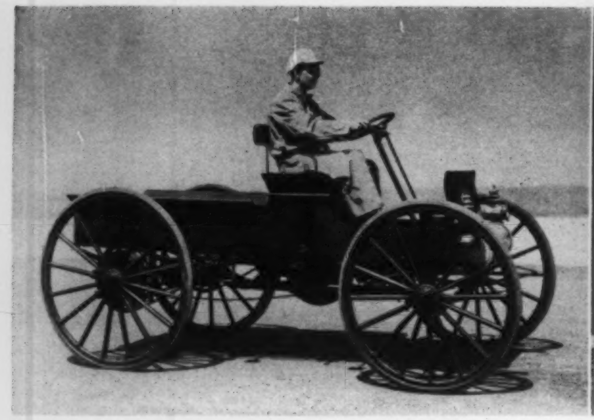
KEEPING UP APPEARANCES ON MAIN STREET

Many truck operators are beginning to consider their vehicle to be, among other things, a rolling advertisement. According to Ford's Walker, "A good-looking truck is its owner's most consistent and effortless means of advertising. Business and industry generally have become increasingly competitive, and anything a business man can do to convince the public he is more able than his competitors is to his advantage. His truck therefore becomes a confidence builder of sorts—a statement of his capabilities."

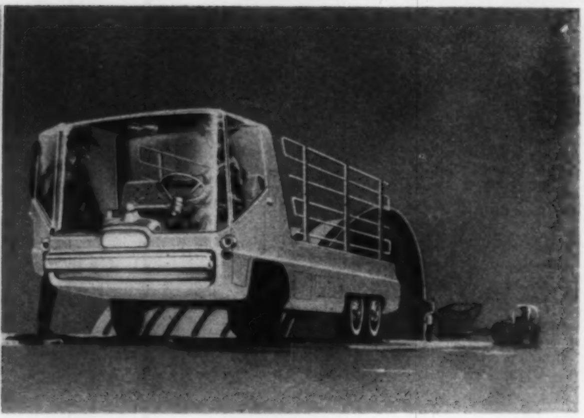
This philosophy is apparently well taken by truck buyers, since it has had a major role in shaping one of the industry's most important decisions—the annual model change. Manufacturers resisted this practice for many years for two good reasons: It was not economically feasible with the low-volume production of trucks, and customer acceptance was not dependent upon appearance.

The truck buyer has apparently changed his perspective, however, and expects the manufacturer to keep pace with the well-styled times. The resulting competition has forced many of the major truck builders to initiate an annual model change, whether it be a complete new design or just a "face-lift."

In the solid, practical world of truck styling, this has been cause for extensive debate, and there are



1907 International Harvester Auto Wagon.
With ventilation, visibility, and plenty of headroom, this model had three basic requisites of good truck styling.



19?? International Harvester . . .
Styling increases utility, and the bare functional cab becomes the "truck driver's office."

still two sides to the question. According to International's Theodore Ornas, "The annual model change does give the stylists the opportunity to create more suitable solutions to truck appearance, and the resulting competitive efforts are bound to achieve an ultimate goal in the 'truck look' that will suit the tastes of the consumer.

"On the other hand, the annual change will meet with resistance from many quarters. Larger fleet owners do not appreciate the obsolescence of their fleets from an appearance standpoint long before they are ready for retirement mechanically. The manufacturer, of course, is faced with the economic problem of getting back the return on his investment for tooling and equipment, with low-volume production."

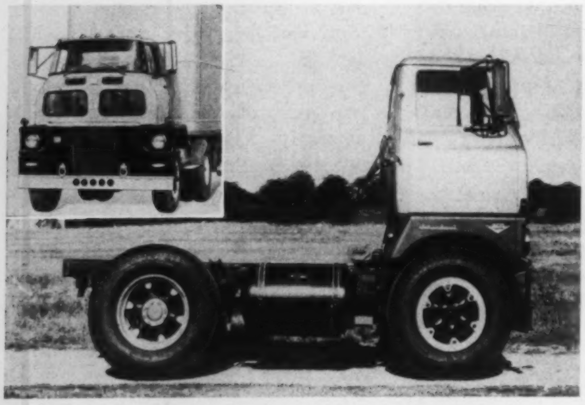
IN THE FUTURE, STRAIGHT DOWN THE MIDDLE

Mechanical limitations and the general "common sense" approach of the stylists themselves denotes a steady pace forward in truck styling, with few radical or abrupt changes. The trend has been established—an efficient combination of appearance and sound engineering.

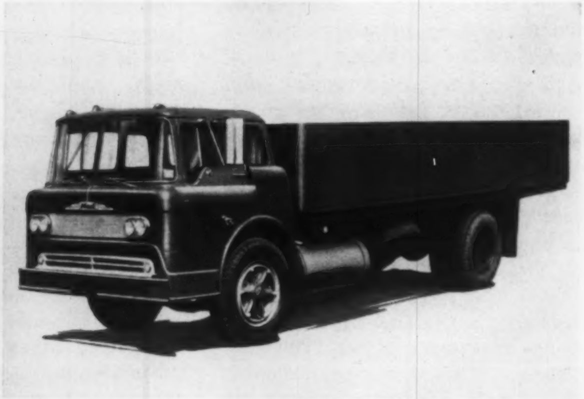
As Mr. Ornas notes, "Whatever shape the motor truck may take in the future . . . the stylist will have to remember that the truck buyer is in business to haul a payload for a profit. It is doubtful that his purchase is motivated by a desire for social prestige, or that styling for style alone is a prime factor in influencing his decision."

—C. E. Wise

TALL AND SHORT . . .

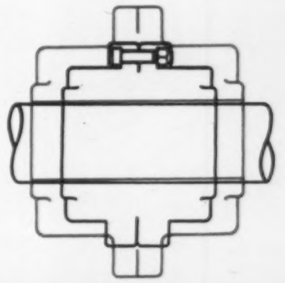


THE LONG, LOW LOOK . . .

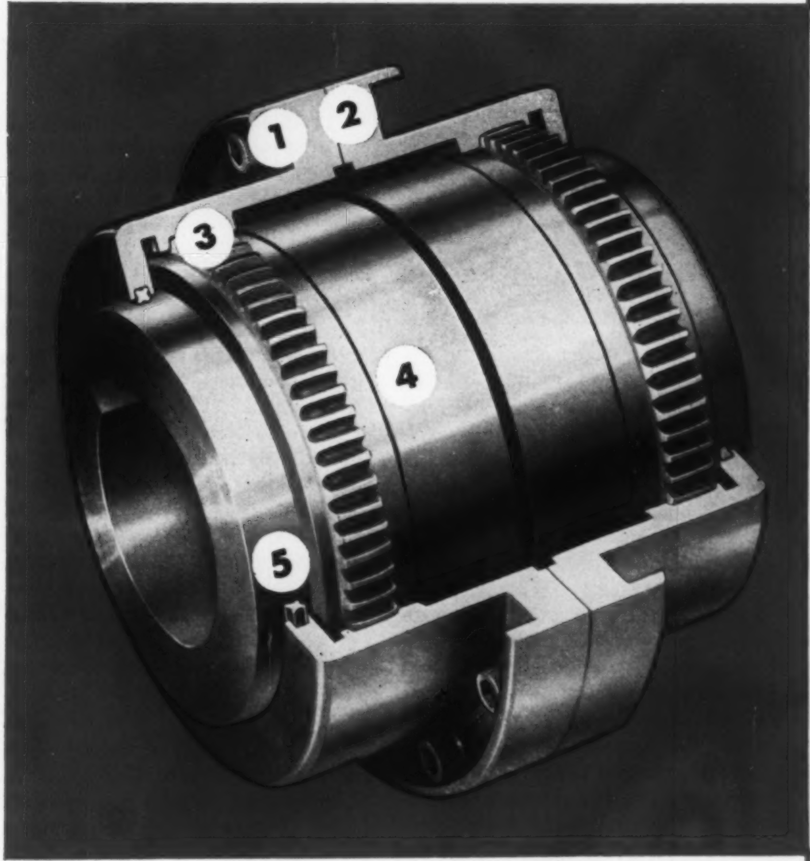


Height of the truck cab is governed by a number of factors—basic is the required bumper-to-back-of-cab (BBC) dimension. Exceptionally small (48 in.) BBC dimension of International's Sightliner highway freighter, left, permits use of longer trailers without exceeding overall length restrictions. Valuable payload capacity is gained. With the same engine, driver, and other components to be contained, the stylist is faced with a tall cab. In this case, height of the cab provided good highway visibility, but created a blank spot immediately ahead and below of the vehicle. A tinted-glass, floor-level windshield was added as an aid to city driving and close clearance maneuvering. The N Model Mack, right, is designed for city delivery work, which means it won't carry big volume loads over long distances. With a comparatively long cab, good city visibility, low clearance, and easy entry and exit for the driver are obtained.

Compactness - -
it's the big difference in geared flexible couplings



Link-Belt geared couplings (black) are smaller, lighter, yet highly capable—provide dependable performance plus savings in space and cost.



These features assure coupling reliability:

1. **SOCKET HEAD FLANGE BOLTS** of hardened steel with ground body securely join housing halves. Locknuts prevent loosening in operation.
2. **FIBER GASKET** fits tightly between flanges. Lubricant can't escape.
3. **PRECISION-CUT** gear teeth have controlled clearance to allow for normal misalignment—minimum backlash.
4. **ALL-STEEL CONSTRUCTION** with properly proportioned parts assures sturdiness, long life operation.
5. **QUAD-RING SEALS** are exceptionally effective in retaining the lubricant. Gearing is always submerged in oil, assuring long, trouble-free operation.

That's why LINK-BELT geared flexible couplings transmit more hp per coupling dollar

COMPACTNESS and high load capacity make Link-Belt geared flexible couplings your best answer for economical power transmission. Size for size, they will accommodate larger, more powerful shafts than other flexible couplings.

These couplings are all-steel and accurately machined for dependability and long life. Hardened flange bolts are ground for close fit. Socket type bolt heads require less of the coupling diameter to be used in the flange—more is available for larger gears and larger shafts.

Compact and rugged — these couplings offer exceptional durability to cope with shock, pulsation, reversing loads and misalignment. For horsepower ratings and dimensions, contact your Link-Belt office. Or write for Folder 2775.

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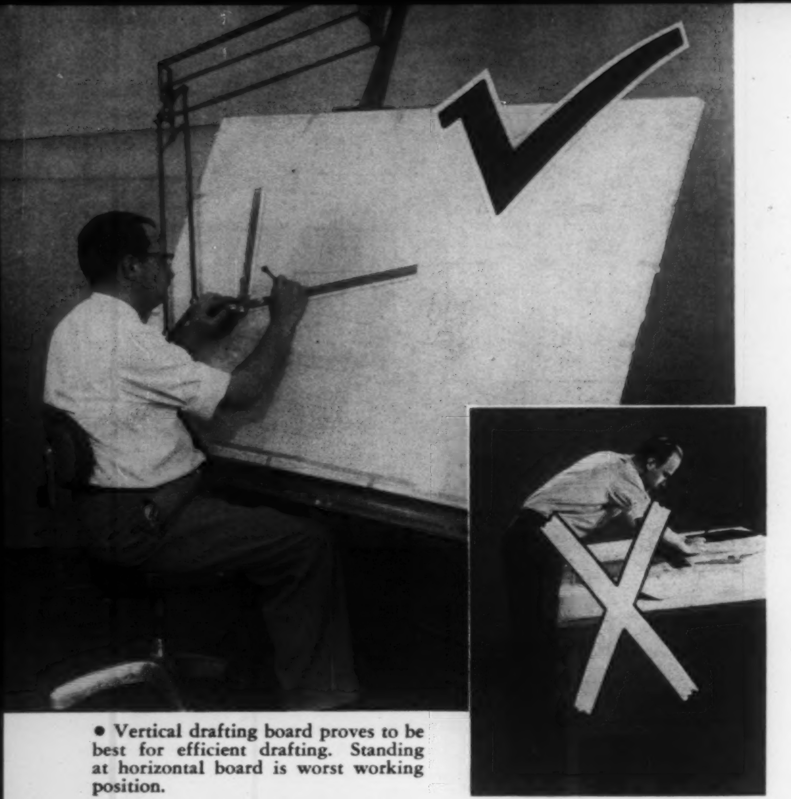
German research study on drafting equipment shows how to . . .

Reduce



• Vertical drafting board proves to be best for efficient drafting. Standing at horizontal board is worst working position.

LIKE TO INCREASE drafting efficiency 25 to 50 per cent? The drudgery of drafting can be eased —and output raised—if the right equipment and methods are used.

These conclusions are based on results from a German research study, published here for the first time. Systematic investigation of working methods shows that type of drafting equipment and position of the drawing board can make a real difference in a draftsman's working speed and efficiency.

Important Factors: Three definite conclusions were reached:

1. Drafting machines are best. In all tests, drafting machines came off with top honors—superior to parallel straightedges or T-squares.

2. Upright boards are more efficient. An upright—rather than horizontal—board position also has definite advantages, although working speed at a horizontal board may be equal for very simple drawings.

3. Changes in working position are least tiring. Correlative investigations of health of draftsmen show, as might be expected, that frequent changes from sitting to standing position are best.

Studies were made at Battelle-Institut, Frankfurt am Main (German affiliate laboratory of Battelle Memorial Institute, Columbus, Ohio) under sponsorship of Franz Kuhlmann K.G.

Test series were conducted with standard drafting machines, drafting machines with adjustable zero-mark heads, rope-guided parallel straightedges, and T-squares. Tests on horizontal boards were made at a tilt of approximately 5 degrees from the horizontal on equipment with no vertical height adjustment and zero to 15-degree tilt adjustment. Upright board tests were made at 60 to 82 degrees from the horizontal.

Results of the tests are shown in the two tables. In all cases, drawings were copied, not traced.

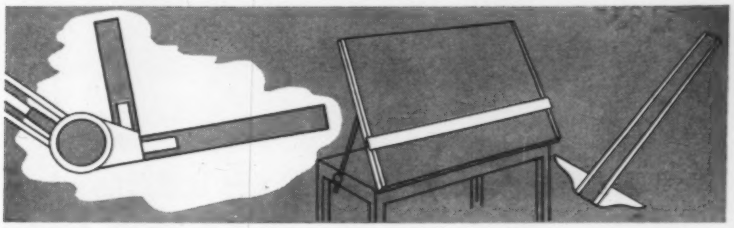
Complex Drawings: For the series of "long-time" tests, three different drawings were used: 1. A manufacturing drawing with the major part of the work from 500 to 600 mm (20 to 23.5 in.) above the bottom edge of the paper. 2. A building construction drawing, size 500 by 1100 mm (20 by 43 in.), with the actual drawing work done at a distance of 100 to 400 mm (4 to 16 in.) from the bottom edge. 3. A more difficult sectional view of a four-stroke combustion engine, containing several angles of varying size and two differently inclined groups.

Times for completion of the manufacturing drawing and the building construction drawing were quite similar, so results have been grouped under one column (*Simple Drawing*).

In these tests, the upright position of the board is the most important factor, as shown by the comparison between working periods for the drafting machine at an upright and horizontal board. For the very complex engine drawing, the adjustable zero-mark head, with its ability to be adjusted to varying angles, proved to be the fastest.

Easy Drawings: A second series of short-time tests was made to eliminate the fatigue factor. These tests, of less than 1 minute duration, were made to eliminate thinking efforts independent of the drafting equipment used, and to attempt to get a picture of the difference between types of drafting equipment. Tests were made after practice by the draftsmen. They represent working time in per cent (upright board with drafting machine = 100) from a large number of tests with several draftsmen. Dimensions of test drawings were checked, and where the number of errors exceeded a limit, the test results were thrown out.

In this series of tests, working time using a drafting machine was



Drafting Drudgery

approximately 27 seconds for the triangle, and 22 seconds for the rectangle.

Most notable difference here is the striking comparison between working times needed for different drawing equipment. The drafting machine proved to have a definite superiority. Position of the board, however, seems to have little or no effect.

Health Affected: Studies also indicate that working position at the drafting board can have quite an effect on health of the draftsman. Certain types of complaints might almost be listed as "occupational hazards" of drafting—particularly headaches, backaches and foot troubles. Respiratory problems occur most frequently, but cannot be labeled definitely as peculiar to draftsmen.

In an interview study of 300 draftsmen and tracers, the most damaging working position was found to be standing at a horizontal board. The stooped position and continuous use of muscles for balancing seemed to have an extreme effect.

Sitting at a horizontal board, or sitting or standing at an upright board, are much better from a health standpoint.

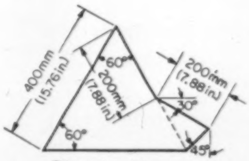
Backaches seem to be the primary problem of the draftsman who works standing up. The sitting draftsman is a sitting duck for headaches, attributed to difficulty of eye focusing on inclined images at varying distances. Almost obviously, the best choice is to vary the working position.

Long-Time Tests

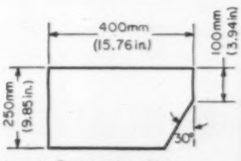
(Working time in per cent)

Type of Board	Type of Equipment	Simple Drawing	Difficult Drawing	Mean
Upright	Drafting machine	100	100	100
	Drafting machine*	100	84	92
	Parallel straightedge	115	125	120
Horizontal	Drafting machine	120	130	125
	Parallel straightedge	130	140	135
	T-square	130	150	140

*With adjustable zero-mark head.



Triangular Shape



Rectangular Shape

Short-Time Tests

(Working time in per cent)

Type of Equipment	Type of Board	Triangle	Rectangle	Mean
Drafting machine	Upright	100	100	100
	Horizontal	98	99	99
Parallel straightedge	Upright	247	189	218
	Horizontal	210	200	205
T-square	Horizontal	225	194	210

Health Hazards for Draftsmen

(Frequency of occurrence in per cent)

	—Horizontal Board—		—Upright Board—	
	Sitting	Standing	Sitting	Standing
Headaches	**52**	**47**	**36**	31
Colds, bronchitis	**38**	**59**	29	21
Backaches	14	**50**	24	14
Foot troubles	10	31	18	27
Constipation	29	**44**	22	14

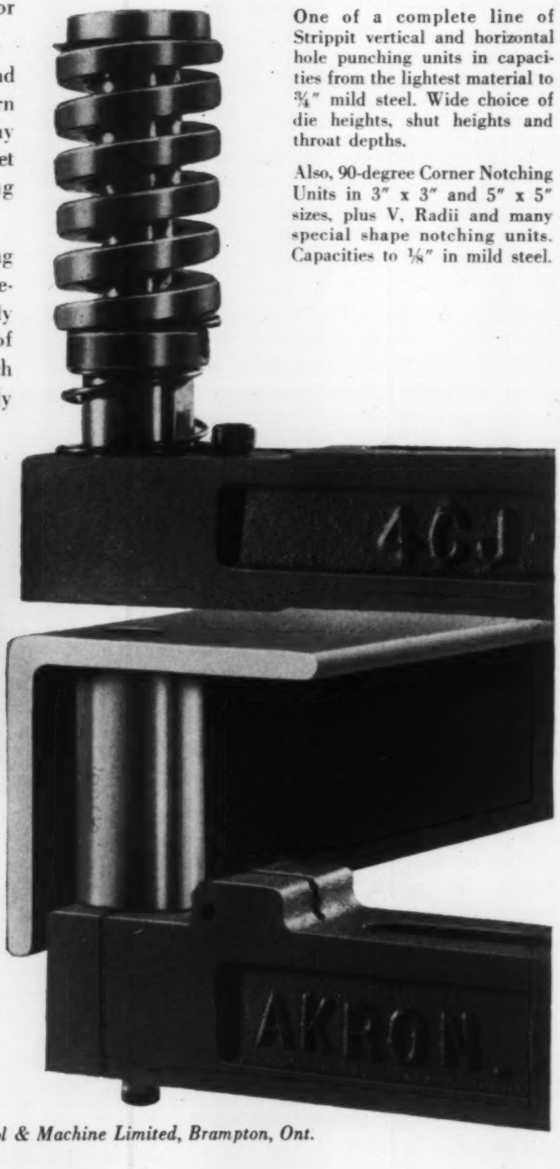
Incidence above 35 per cent in bold type.

Maximum freedom of design with versatile STRIPPIT *tooling!*

You can design any pattern of round, square, obround or special-shape holes — plus any type of notching — in flats, structurals or extrusions — and know that production can handle it with swift economy using STRIPPIT tooling, either on pilot or production runs!

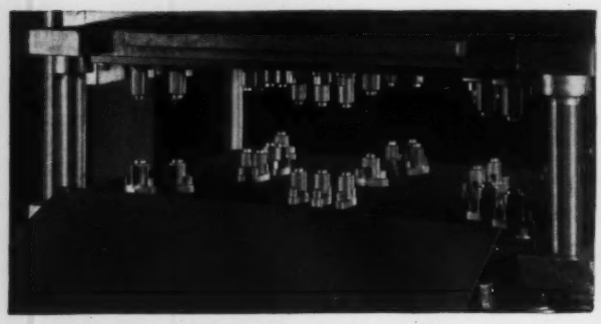
Strippit self-contained, self-stripping punching and notching units can be set up in any template pattern within press capacity — placed in the press for any length of run with little down-time — quickly set up in new patterns. Other Strippit cost-cutting advantages include:

• The effect of quick-change dies without die-making or die-spotting • Speed over drilling — plus no deburring • Units re-usable over and over • Readily removable punches and dies • Ease, accuracy of template mounting — pilot pin centered on punch • Each unit complete — permanently aligned, fully guided, self-stripping.



One of a complete line of Strippit vertical and horizontal hole punching units in capacities from the lightest material to ¾" mild steel. Wide choice of die heights, shut heights and throat depths.

Also, 90-degree Corner Notching Units in 3" x 3" and 5" x 5" sizes, plus V, Radii and many special shape notching units. Capacities to ⅛" in mild steel.



For unlimited feeding of work, Strippit Type CD and JD (heavy-duty) Punch and Die Assemblies are readily template-mounted to press ram and bed in any desired pattern.

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Special tools made up to your specifications.
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Manufactured in Canada by Strippit Tool & Machine Limited, Brampton, Ont.

Individual managers suggest these specific ways . . .

. . . TO IMPROVE COMMUNICATIONS:

"The greatest basic need is for more concise reports in which conclusions and recommendations are clear, and basic data can be reviewed readily when necessary."

"If research engineers had a better commercial understanding and would interpret their works relative to profitability advantages either for the company or their customers, it would be most helpful."

". . . develop better understanding by the laboratory worker as to just *why* he is working and *what* are his specific objectives."

". . . fixing oral reporting dates. Reports (written) do not usually present opportunity for philosophizing or passing management viewpoint on to R & D at time of reading."

"Improvement in quality and in uniformity of reporting procedures and measurement of results."

"Abstract reports."

"Scheduled demonstrations of experimental progress."

". . . it may be that management needs to improve its communications to scientists. . . . If our scientific staff understands our management policies, we believe their reports will be made to implement our policies as much as possible."

. . . TO IMPROVE LABORATORY REPORTS:

"Laboratory recommendations as to what should be done should be specific as to context and as to who should carry them out."

"If it were possible to separate all preliminary work, testing procedures and results, discussion of pros and cons, and other phases of the work from the final analysis, much greater reader attention would be obtained. This is not a simple problem because the reader demands justification for the conclusions drawn."

"Increased use of photographs to illustrate test apparatus, specimens, results, etc."

"More data reduced to tabular form."

"More time and thought in making reports."

"More expeditious documenting of laboratory findings."

"Cover more adequately those studies indicating probable eventual unsuccessful results to allow for eliminating unfavorable progress investigations sooner."

Company executives seek

More Helpful Research Reports

Most managers want improvement in written and oral presentations. Here's how.

BEST WAY to improve technical reports prepared by research and development laboratories for top management is to make reported conclusions more meaningful. This, itself, is a conclusion from findings in a recent survey conducted by the Scientific Apparatus Makers Association. SAMA had asked 500 executives in 34 different kinds of industries how they thought communication of technical matters could be improved between their own offices and their company laboratories.

The managers rated two other matters nearly as important as meaningful conclusions. They want more stress given to the far-reaching implications of reported results, and they want report authors to pay more attention to the dollar and marketing values of research findings.

To lesser degrees, managers complained that reports are too long and too scientific. They want reports written in "better English"—phrased in the "language of the laymen." They think reports should have more graphic material; more understandable statistics. Only about 15 per cent of the survey respondents considered present R & D reports satisfactory.

Of the companies contacted in the survey, half reported that one research report serves all operating departments (sales, finance, advertising). The other half require separate reports on each development, tailored to the needs of respective company-division executives. Most reports are written, but the most significant research developments are reported orally and promptly. Seldom are both written and oral presentations combined.

In the survey returns, most suggestions that concerned improvement of communications between engineers and management fall into four groups:

- More frequent reports.
- More personal contact.
- More discussions and study groups.
- Special groups to study communication.

Replies indicated that management endorsed more personal contact but that this imposed more demands on schedules already crowded. Immediate benefits from more personal contact and more discussions should be a "freshening" of attitudes all around and the timely avoidance of commercially "blind" avenues.

Groups to study methods of communications are favored if they can be justified by company size. Another arrangement, reported successful by one company, is the appointment of a liaison "research co-ordinator."

The

MUCH of what has been called hoarding on the part of industry is nothing more than the miscalculation of needs and requirements for engineering manpower. The survey, *Engineering Manpower,* on which this series is based, verified a number of instances.

Engineers were found to be working in libraries where they clipped technical reports from journals; in training and indoctrination programs where they filed drawings or worked in plant cafeterias; and on jobs where they "temporarily" prepared charts and posters.

Mass engineering

The use of excessively large engineering teams in a "mass engineering" approach has been cited as a factor contributing to hoarding or stockpiling. Mr. J. M. Bridges, Director of Electronics, Office of the Assistant Secretary of Defense, has said that various companies differ substantially in the number of engineering manhours applied to jobs of similar magnitude and time scale, with manhours differing by as great a ratio as four to one. He observed that a multiple engineering approach has often been used for even the simplest and most straightforward design tasks. He also pointed to a lack of sufficient numbers of technicians to support

Checkpoints for Engineering Management

☑ **1. Does your department sometimes find itself engaged in "mass engineering"?**

☑ **2. Can some engineers, because of their training or abilities, be better employed in more difficult work?**

☑ **3. Do you have an effective way to assess validity of engineering manpower requirements?**

☑ **4. Are engineering programs adequately planned to control staff size?**

☑ **5. Is the level of technical and administrative training and experience on the engineering staff sufficient to detect stockpiling?**

Superfluous Engineer—

Product of Stockpiling

the professional engineers. He found the ratio of technicians to engineers to vary from 3:1 to 1:3 on essentially the same kind of work. According to Mr. Bridges:

> - Much of the incentive for the mass-engineering approach seems to stem from the flexibility permitted under the cost-plus-fixed-fee type of contract and from the fact that the project is managed by inadequately trained people in the military agencies. Generally, military project managers are not sufficiently competent in engineering management to recognize that the contractor's practices are failing to make effective use of engineers and to give the government the best return for its money.

Government contracts and the technical staff

The survey bears out his comments on military project managers. Prior to the letting of a contract, the bidder is visited by one or more government representatives charged with administering the contract, who conduct a "plant survey" to determine whether or not the company appears to have the necessary physical equipment and technical staff.

However, a number of executives and supervising engineers in companies engaged in government work complain that government inspectors making such surveys apparently have no way of judging the competence of the technical staff. Too often they make their tests for adequacy on the basis of numerical criteria. They appear to judge on the basis of numbers especially for firms seeking government contracts for the first time.

The result has been that a firm may have to hire, or maintain on the payroll, superfluous technical personnel to make a presentable appearance. This was found to be

Recommendations for Management

1. Question "mass engineering."

Check the need for mass engineering wherever used. The multiple approach to engineering problems wastes manhours and money unless project complexity absolutely requires this approach. Signs of mass engineering are lack of engineering accountability, poorly directed efforts, and duplication of portions of projects.

2. Assess engineering needs.

The amount of unconscious and inadvertent stockpiling in industry is considerable. Unnecessary people are hired when management has no effective way of judging engineering manpower requirements.

3. Modernize hiring techniques.

The hiring techniques employed by many companies are ineffective. Very often they result in hiring personnel who are less suitable. For best results, combine engineering and personnel department evaluations.

4. Check government policy.

Endorse and support modification of government policies that "allow" costs for artificial competitive pressures. Responsible businessmen can do much to ameliorate hoarding.

5. Notice cost contracts.

Faced with engineers who lack experience and competence in a particular line of design, project managers may tend to override shortcomings by sheer use of numbers and by assigning small segments—and duplicate segments—of the work to each engineer or group. Under these conditions, engineers are essentially trained to low productivity and little responsibility. This situation can very well go unnoticed by management when cost-plus contracts still show profits.

especially true in basic research. One cynical executive made the following statement:

> • Government contracts are the easiest thing in the world to get if you only know how. First you pack your plant with engineers and research scientists and then find the contract offered which is difficult enough so that few others will bid for it. Then you bid on that and with the proper preparation the plant survey men from the government could not fail to be impressed by your capabilities. Inevitably you get the contract.

This comment reflects an attitude described by Mr. Bridges:

> • In fact, a persistent feeling is growing among contractors that development contracts are awarded on this basis and that they must build up big engineering organizations if they are to be eligible to receive contracts. This probably accounts for much of the prevalent engineer hoarding, and is probably a substantial factor in "job jumping," "pirating," and the generally unsettled conditions in the engineering profession today in industries dealing extensively with the government.

In some plants queried, government contract supervisors have, in fact, been responsible for causing rather than eliminating overstaffing. The stockpiling has occurred in spite of the checks built into the procurement system in the form of the audit. This suggests that the auditor alone is not qualified to pass on the adequacy of a contractor's technical staff.

Tax Deductions
PHD
PHD
PHD
PHD

Tax advantage and competitive position

Stockpiling also occurs in some companies because there is a tax advantage to it. Engineers' salaries are deductible as expenses of course, and the accumulation of well-trained technical personnel serves to enhance the company's future competitive position. The companies practicing this kind of hoarding tend to regard it as insurance against technical competition and concentrate on accumulating large groups of outstanding people.

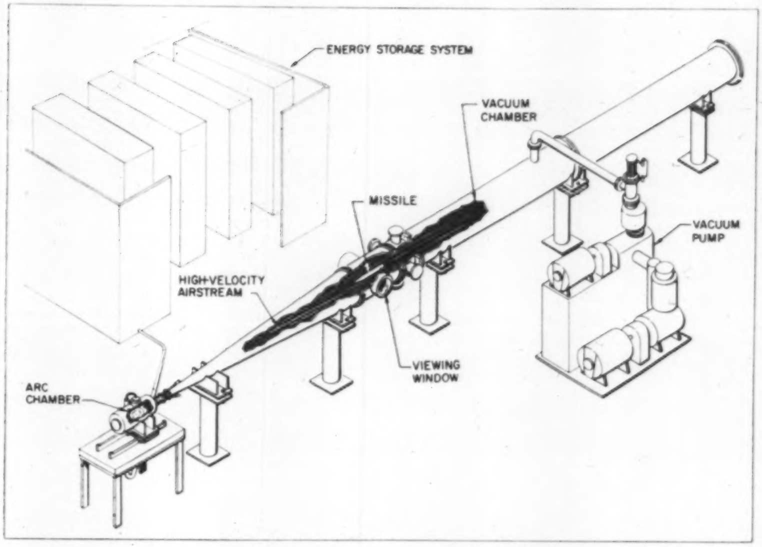
The survey encountered only few companies engaged in this type of hoarding. One reason for this may be that too many high-quality people concentrated in proximity to each other tend to clash. An executive in one company which was attempting to stockpile in this way complained:

> • Our people are very degree conscious. It really causes trouble. When you get one fellow with a Ph.D. in one field he always seems to feel superior to Ph.D.s with degrees in other fields. You put three or four of them together and they fight like cats and dogs. No one wants to submit to the leadership of the others.

With a number of companies contacted, the problems involved were legitimately such that only highly trained people could handle them. These men invariably received adequate technical support from technicians and other personnel in an over-all effort that represented competent technical staffing.

Next article in this series will appear in the March 13th issue. It will deal with the training of engineers, both in-plant and outside, and with company programs and approaches for training.

ALL THAT GLITTERS IS NOT CHROME on 1958 automobiles. Buick Roadmaster, left, has 74 aluminum trim and functional parts which weigh 116 lb. Auto industry's use of aluminum in 1958 averages 52.4 lb per car, up 29 per cent from last year. Similar, increasing use of stainless-steel parts is illustrated, right, by 170-piece selection used on new Dodges. The hardtop above has 47 stainless structural and trim parts.



HOTSHOT wind tunnel being built at Lockheed's missile research laboratory will reproduce 15,000-mph speeds and 18,000-deg temperatures for simulation of highspeed missile flight. Compressed gas in the arc chamber, left, is fired by a 20-million kw jolt of electricity. Gas is heated instantly to 18,000 F, pressure reaches 30,000 psi, and the gas erupts through a diaphragm, explodes through the 44-ft evacuated tunnel, and blasts against a test missile. Sparkplug for the Hotshot, which provides 1000 times the peak electrical power demand of a city of 50,000 population, consists of 320 condenser units packed in a room 24 ft square.

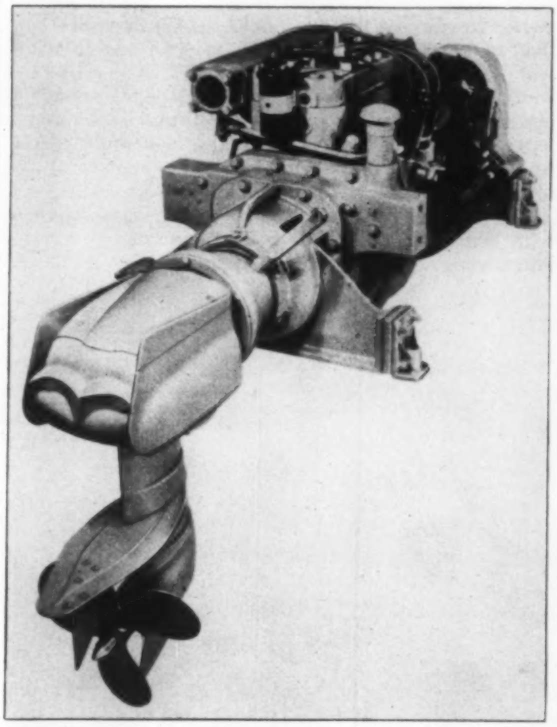
Unburned Fuel Dilemma Plagues Auto Design

Five Test Cars in Study

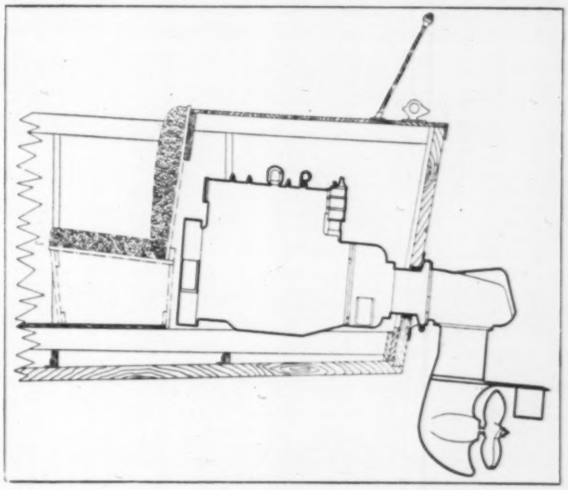
DETROIT—The dilemna of unburned fuel evaporating from auto carburetors involves carburetor design, fuel chemistry, traffic conditions, and hot weather, according to Joseph T. Wentworth of General Motors Research Staff. His study was based on five test cars outfitted with standard carburetors and special apparatus for trapping and measuring gasoline vapor. They were driven about Detroit and Phoenix, Arizona.

First, Wentworth declared, some carburetor vent system is necessary because gasoline is a volatile liquid. Its vapor pressure depends on temperature.

Carburetors must be designed to "let off steam" occasionally, depending on driving conditions and air temperature. One way to relieve pressure is to vent the vapor externally through a hole in the



Z-DRIVE OUTBOARD ENGINE is in the boat; the drive is outside. The unit gets its name because engine power is transmitted through a Z drive arrangement. Manufactured by Norseman Marine, this new power plant fits in outboard motor wells, under decks, or in boxed seats. Maneuverability is claimed to be exceptional because the boat is steered by the outboard drive, not by a rudder. It was developed to power fast runabouts, family cruisers, and utilities.

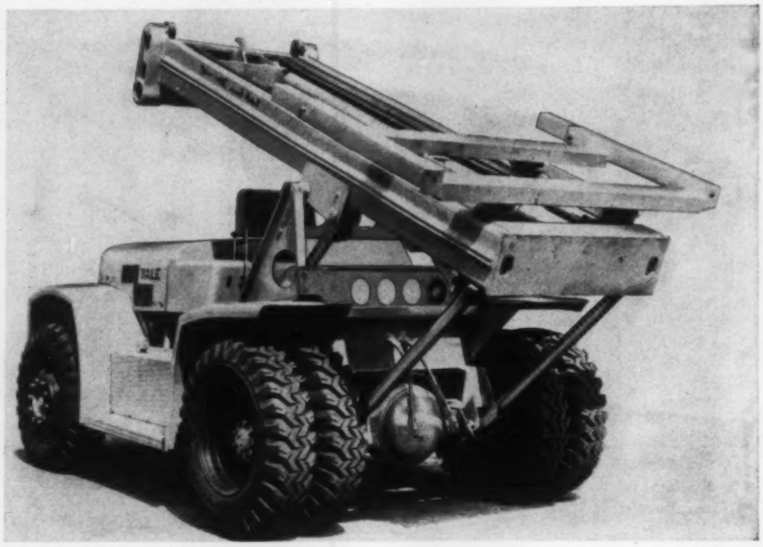


IN-AND-OUT ENGINE delivers up to 70 hp. Engine is four-cylinder, four-cycle, water-cooled type, with gas consumption claimed to be less than 4 gal per hr. Norseman Marine's Outboard Z-Drive does away with inboard propeller shaft, stuffing boxes, struts, and rudder assembly. No keel bore is required. With engine installed, runabouts and cruisers can be beached and trailed by swinging drive up completely, clearing the boat bottom. Engine has pushbutton electric starting as standard equipment, and built-in generating system.

top of the float bowl, which obviously releases fuel vapor into the atmosphere. How much this contributes to air pollution is undetermined. Another way is to vent the vapor internally so that it feeds from the carburetor back into the engine's intake manifold. But this creates a "hot starting" problem by making the mixture too rich and gives the engine a rough, sputtering idle.

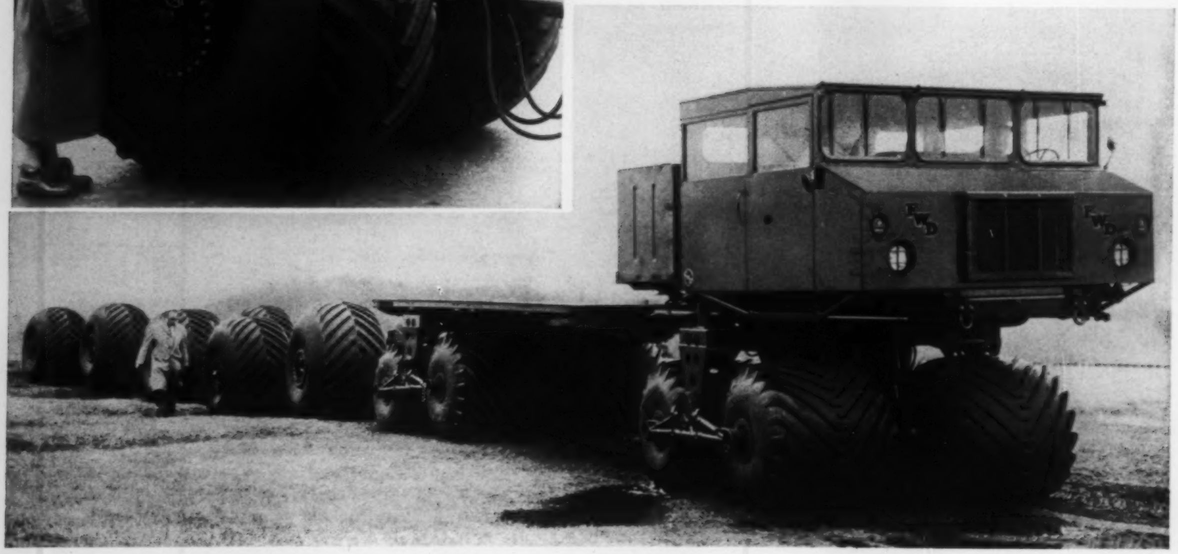
Thus, Wentworth explained, the carburetor designer faces a dilemma: He may minimize his problems with one of two types of venting systems. But he can solve neither problem satisfactorily.

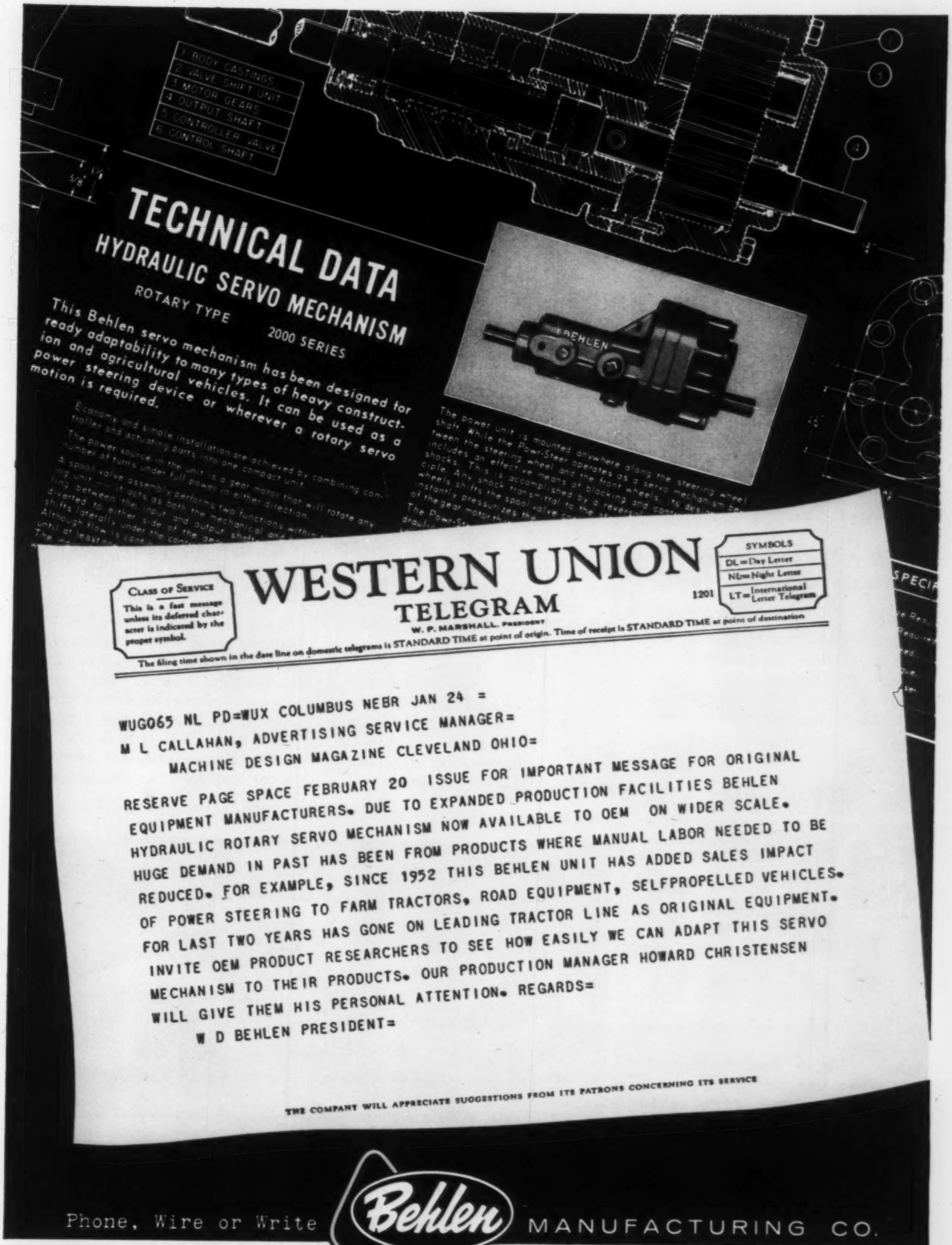
He urged that both petroleum and automotive engineers consider air pollution, engine idling performance and fuel economy as interrelated aspects of carburetor evaporation. Both groups should try to "narrow the gap between what the automobile is built to utilize . . . and what the automobile gets in the way of a gas diet."



FOLD-DOWN MAST on this Yale & Towne 20,000-lb capacity lift truck eliminates low-clearance problems in shipping the truck via commercial carrier or in driving it over-the-road under its own power. Mast height is reduced from 206 to 136 in. on some models; from 158 to 118 in. on others. Fold-down of the channels is done in 30 min with a standard automotive hydraulic jack and a kit consisting of two struts and two braces. After placement of the initial braces and disconnection of the mast assembly by use of the jack, the channels are lowered through action of the tilt cylinders.

ROLLING FUEL TRAIN towed by a pillow-tire truck can transport 5000 gal of fuel or other liquids over terrain inaccessible to conventional tank trucks. Developed by Four Wheel Drive Auto Co., the fluid transporter consists of ten 500-gal capacity rubber-tire bags that range in height from 3½ to 5 ft and in width from 3½ to 7 ft when fully loaded. The Goodyear containers are mounted in pairs on special axles and towing assemblies. Each two-wheel unit is equipped with filling, emptying, and braking systems. Capacity of the train is limited only by pulling power of the towing vehicles, and containers can be towed after removal of their liquid cargo by simply tapping them with air pressure. The train is operational in temperatures ranging from −65 to 125 F.





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This Behlen servo mechanism has been designed for ready adaptability to many types of heavy construction and agricultural vehicles. It can be used as a power steering device or wherever a rotary servo motion is required.

Economy and simple installation are achieved by combining controller and actuating parts into one compact unit.

The power source in the unit is a gear motor that will rotate any number of turns under full power in either direction.

A spool valve assembly performs two functions within

The power unit is mounted anywhere along the steering wheel shaft. While the Powr-Steer operates as a servo mechanism between the steering wheel and the front wheels, its design includes an effective means of blocking and con

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RESERVE PAGE SPACE FEBRUARY 20 ISSUE FOR IMPORTANT MESSAGE FOR ORIGINAL EQUIPMENT MANUFACTURERS. DUE TO EXPANDED PRODUCTION FACILITIES BEHLEN HYDRAULIC ROTARY SERVO MECHANISM NOW AVAILABLE TO OEM ON WIDER SCALE. HUGE DEMAND IN PAST HAS BEEN FROM PRODUCTS WHERE MANUAL LABOR NEEDED TO BE REDUCED. FOR EXAMPLE, SINCE 1952 THIS BEHLEN UNIT HAS ADDED SALES IMPACT OF POWER STEERING TO FARM TRACTORS, ROAD EQUIPMENT, SELFPROPELLED VEHICLES. FOR LAST TWO YEARS HAS GONE ON LEADING TRACTOR LINE AS ORIGINAL EQUIPMENT. INVITE OEM PRODUCT RESEARCHERS TO SEE HOW EASILY WE CAN ADAPT THIS SERVO MECHANISM TO THEIR PRODUCTS. OUR PRODUCTION MANAGER HOWARD CHRISTENSEN WILL GIVE THEM HIS PERSONAL ATTENTION. REGARDS=
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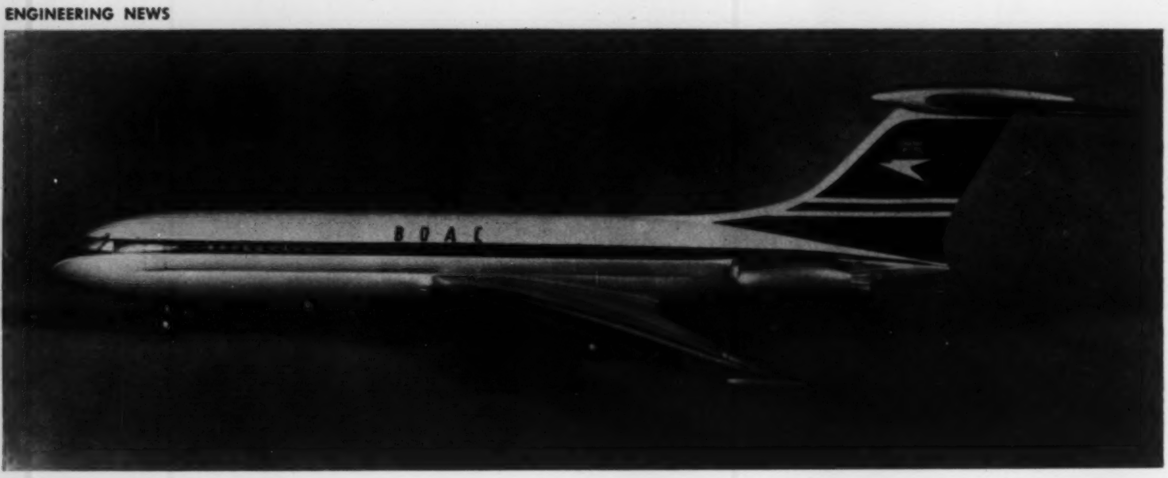
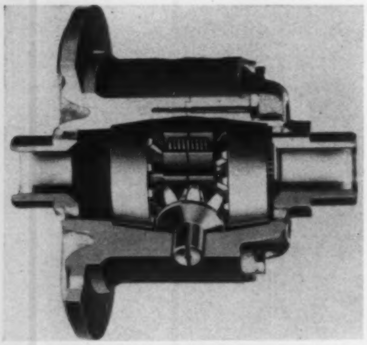


REAR-MOUNTED ENGINES on Britain's new jet airliner, the Vickers VC-10, leave the wing clean and unbroken with room for flaps and leading-edge slats across the entire span. This feature also reduces cabin noise and vibration. Designed by the maker of the Viscount turboprop, the VC-10 will carry 150 passengers; become operational on many world airlines in 1963. Originally designed for medium-range service, the plane's four specially developed Rolls Royce Conway bypass engines were improved enough in performance to extend its range. Key features of the VC-10 are its outstanding takeoff performance and operational economy.

New, Nonslip Car Differential Has Simple Design, Few Parts

CHICAGO — A new spin-resistant automotive differential, developed by Borg-Warner Corp., is said to increase traction on snow and ice, reduce skidding on curves, diminish swerving on rough, crowned roads, and reduce tire wear due to wheel bounce.



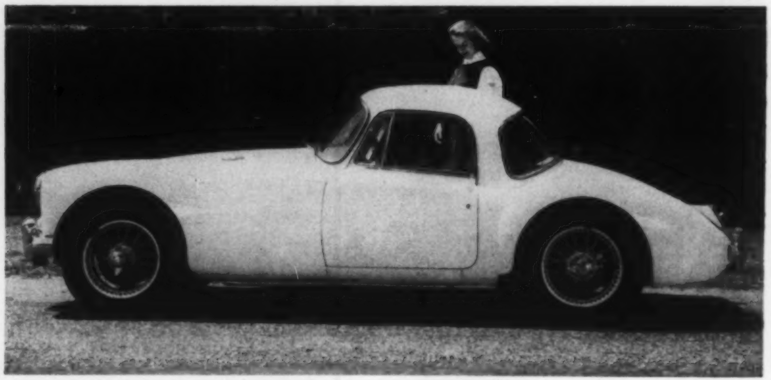
According to Borg-Warner officials, the new unit is simpler in design, has fewer parts, than others of its type now on the market, and unlike similar differentials, is so designed that it cannot cause full locking of one axle shaft.

In operation, the new differential automatically delivers the major portion of engine power to the wheel with more traction. At the same time, the wheel with lesser traction is braked through the action of preloaded cone brakes and side gear thrust. When traction is equal at the rear wheels, as in normal driving, the unit operates as a conventional differential.

Now under test by several of the major auto manufacturers, the unit is interchangeable with most conventional differentials and was designed for use on cars, trucks, tractors, construction machinery, and industrial lift trucks.

Fast New Computer Speeds Missile Research

WASHINGTON — The first digital computer claimed to be fast enough to evaluate the performance of a missile in full flight will be used for missile design studies at the Army's Redstone Arsenal. Known as TRICE, for Transistorized Real Time Incremental Computer, Expandable, the new computer can solve a complete set of



MG MODEL "A" for 1958 offers 100-mph sports car performance plus hardtop weather protection and wrap-around windshield. A four-cylinder, 1489-cu cm engine with dual carburetors provides 72 hp at 5200 rpm. Over-all height of the low-slung two-seater is 50 in.; length is 156. Direct rack and pinion steering responds instantly to turning; self-centering front wheels recover from turns fast and naturally. Front suspension uses independent coil springs with hydraulic shock absorbers, rear suspension has semi-elliptic springs and hydraulic shocks. The small car's sturdy, box-frame chassis is well braced for torsional rigidity.

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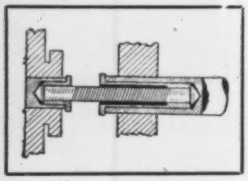
(Advertisement)

FLEXIBLE SHAFT COUPLING

for Industrial Design



Coupling is used for the transmission of power or control of movement between parts located close together in a piece of equipment. It is not a separate type of flexible shaft but rather an added application of flexible shafting.

The coupling can be composed of either power drive or remote control flexible shafting although the latter is generally used due to the added advantage of its ability to rotate both clockwise and counter clockwise. Generally used between two units which are but a few inches apart, coupling may transmit power between any two parts regardless of their relative positions.

For example, the diagram above shows an advantage in using small lengths of flexible shafting in a coupling application. Although the drive end and the driven end are not exactly in line, the coupling compensates for the difference in alignment between the two.

Many manufacturers use flexible shaft coupling even where parts may be connected by solid shafts because of the savings realized in the initial and the maintenance costs as well as in time and labor.

For complete information on how flexible shaft couplings may help improve your product design, write F. W. Stewart Corporation, 4311-13 Ravenswood Ave., Chicago 13, Illinois.

Circle 418 on Page 19

equations every 10 microseconds. This is 24 times faster than other available digital computers, according to Packard-Bell Electronics.

Evaluation of dynamic systems such as those involved in the control of missiles, has previously been performed by analog computers, since the more accurate digital computers have been too slow.

Defense Digest

D-558-Phase III, being developed by Douglas Aircraft, will be an extremely advanced rocket-powered space-research vehicle. It will be manned and employ booster rockets to reach altitudes of more than 135 mi. It could be placed in orbit for brief duration. No dates for first trials have been released.

• • •

Standby armament program for the Army includes a new automated shell-filling line at Joliet Arsenal. Substantial quantities of 75 and 90-mm ammunition can be loaded daily at the flick of a switch in event of emergency. Built by AMF, the fully automated line is divided into 12 stations, all of which are monitored by a single operator sitting at a control console. In addition to elaborate instrumentation, the operator watches five TV monitors that tie in with cameras focused on critical processes. Minimum personnel are needed during either standby or full production operations.

• • •

New Army missile, called *Pershing,* will soon be developed to replace the tactical, short range *Redstone.* Using solid propellant fuel, *Pershing* will retain *Redstone's* mobility and accuracy, but will be smaller, lighter, and easier to handle.

• • •

Miss-distance indicator, developed by Naval Ordnance Lab, will speed and improve training of antiaircraft missile crews. The new electronic system consists of three VHF radio units: a transmitter in the missile, a receiver-recorder on the missile-launching ship, and a transponder, or relay station, in the target. When missile is fired, its transmitter signals both the target and the launching ship. Transponder in the target retransmits the signal, on a different wave length, to the launching ship. Recorder on the launching ship compares difference between the two signals and shows distance, in feet, between target and missile at point of closest approach.

Pied Piper Project is being accelerated by Air Force and Lockheed Aircraft, with first launching date scheduled for late 1958. *Pied Piper,* also known as WS-117L and ARS, for Advanced Reconaissance Satellite, is a massive and elaborately equipped satellite designed to orbit 800 to 1100 mi from earth with TV scanners and facilities for transmission to ground stations. Air Force hopes to have a manned WS-117L in space by 1960; admittedly optimistic, but possible at rate of current development. Success of *Pied Piper* depends on other space projects: Douglas D-558-Phase III and North American X-15.

• • •

Atomic armament will be carried by Air Force F-101B all-weather fighter. This two-seater version of McDonnell's F-101A *Voodoo,* which recently set new world speed mark, will mount the Dougas *Genie* missile. *Genie,* formerly called *Ding Dong,* will give the F-101B capability of "downing entire formations of enemy bombers."

• • •

X-15 manned research vehicle is nearing completion by North American Aviation and is scheduled to be flown in 1958. A 60,000-lb thrust liquid-propellant motor will power it from air-drop to 520,000-ft altitude. Speed is expected to be between 7000 and 9000 mph. X-15 features "variable geometry" wings; has artificial cockpit illumination to overcome "glare out" at extreme altitudes where atmosphere is too thin to diffuse light. The vehicle will use jet reactors for control in thin air.

• • •

No operational ICBM by 1959, is the opinion of missile-industry experts. Officials of Convair, prime contractor for *Atlas,* termed Pentagon predictions as "too optimistic" following Air Force Secretary Douglas' announcement to Congressional groups that *Atlas* would be ready for use in late 1959. *Titan,* the only other ICBM being developed, is reportedly a year behind *Atlas.*

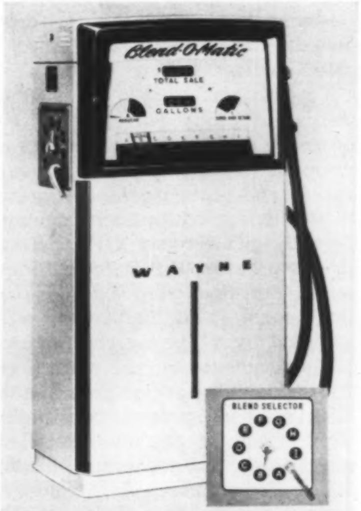
Pump Blends Two Gasolines, Gives Multigrade Output

Mixes Fuel to Suit Car, And Operating Conditions

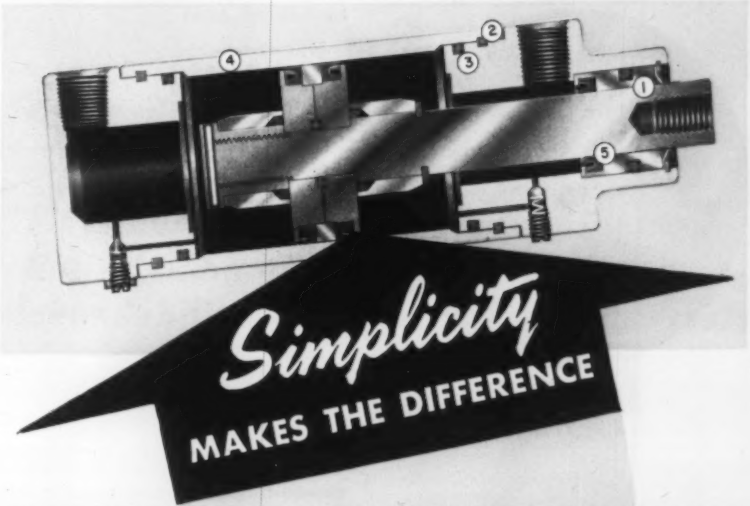
SALISBURY, MD.—A new gas pump automatically blends fuel to suit each car and its driving conditions. In effect, it makes a multigrade gas station from a two grade system. The pump, manufactured by the Wayne Pump Co., will deliver any one of up to nine different grades of fuel. These range from regular to superhigh octane, and up to seven blends of these grades.

Setting the selector lever automatically makes the necessary adjustments of the pump mechanism to deliver the blend desired. This blend is indicated by the position of the selector pointer and also by the sale indicator on the dial face of the pump.

Design features include two low-speed, positive-displacement, internal-gear type pumps with built-in adjustable bypass valves. Hose-within-a-hose construction gives concentric flow of gasolines to nozzle for dispensing.



In blending gas pump, operator can set blend selector for 100 per cent of regular grade; $87\frac{1}{2}$ per cent of regular and $12\frac{1}{2}$ per cent of superhigh octane; and so on in $12\frac{1}{2}$-per cent increments up to 100 per cent of superhigh octane. Total price of each sale is registered by the pump's computer, based on blend sold.



why **CARTER CYLINDERS** give you longer life, simplified maintenance, 40% savings in space and—
IMMEDIATE DELIVERY TOO!

CHECK THESE DESIGNERS' FEATURES:

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2. **Key type stainless steel locking ring; Strength plus 360° orientation of pipe ports.**
3. **Leakproof service.**
4. **Precision honed heavy wall tubing—6 to 1 safety factor.**
5. **Self adjusting packing; Low friction breakout!**

PHONE: BAyport 1-7186 (Chicago)

The Carter line is engineered to give you the best cylinder! Strong, modern construction! No tie rods or bolts—a strong, simple key lock between head and wall lets you orient pipe ports a full 360°. Compact size gives you more space and flexibility in design.

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Complete designers' file gives specifications and details on all models. Send today!

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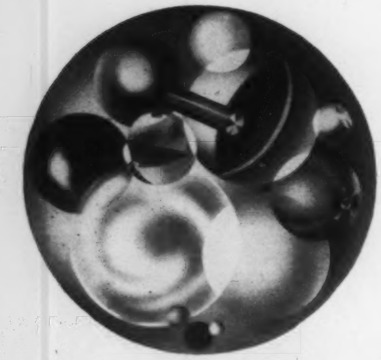
2914 Bernice Road • Lansing, Illinois (Chicago Suburb)
AIR CYLINDERS • AIR VALVES • HYDRAULIC CYLINDERS
ROTARY ACTUATORS • SPECIAL CONTROLS



BALLS UNLIMITED

Whatever you can dream of in precision balls, we can bring your dream to reality; for ITI balls are available in . . .

ALL MATERIALS

including special ferrous and non-ferrous alloys, plastics, ceramics, carbides, titanium, synthetic sapphire.

ALL SIZES

standard and special, from .005" to 24" diameter or more, depending on the material.

SMALL OR LARGE QUANTITIES

— from a handful to millions.

HIGH PRECISION

— to .000005" if desired, depending on size and material.

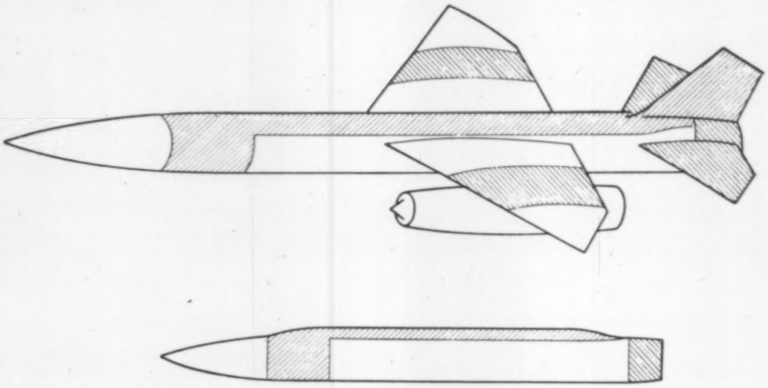
IN ADDITION

we make balls with stems, slots, grooves, tapped holes — ball segments — hollow and plated balls. *If it has a spherical surface, you can count on us to produce it.*

Write for quotation and literature on items of interest.

INDUSTRIAL TECTONICS, Inc.
ITI
MANUFACTURERS OF PRECISION BALLS AND BEARINGS
3688 Jackson Road, Ann Arbor, Michigan

Circle 420 on Page 19



TOUGH SKIN for the Bomarc interceptor missile is fabricated from magnesium-thorium alloys—a recent application of the metal reported by Dow Chemical Co. The 7500-lb missile uses magnesium-thorium sheet, extrusions, and castings to trim weight and withstand high temperatures. Magnesium-thorium (HK31 alloy) sheet forms half of the upper wing surface, a third of the lower wing surface, entire upper and lower elevator skins and doublers, and entire fin and rudder skins and doublers. Nose section skin and doors made with the new alloy result in a weight saving of 9.5 lb. HK31 sand castings include a door frame and equipment-mounting structure in the aft body section which save 6 lb over original design materials. Extrusions are used for leading and trailing edges of all control surfaces where high strength-to-weight ratio and resistance to heat are required.

Missiles General Equates Leadtime to Leadership

Supports Healthy Disrespect For Red Tape

New York — The U. S. can overcome the dangers resulting from recent Soviet advances in the fields of missiles and space technology sooner than some think. In this new space age, the equation for survival is "leadtime equals leadership. . . The original investment required for preliminary projects in space flight has already been made in our Air Force ballistic missile program. . . If starting today from scratch, we were to attempt to duplicate these existing assets and capabilities, we would need more than 4 years in time and $4 billion," said Major Gen. Bernard A. Schriever, ARDC Ballistic Missile Div. Commander, in a recent talk before the Economic Club of New York.

He pointed to a complete break with tradition in the management of the Air Force missile program. The usual procedure, which is to build a new weapon in a series of consecutive steps, was discarded. Instead, missile program administrators took the calculated risk of planning, programming, and spending their funds concurrently, on research, development, testing, production, manpower training, and base construction.

The General briefly sketched a picture of people currently in the program, "In manpower our program has called upon 18,000 scientists and other technical experts in the university and in industry. Directly and actively participating in our program—from front office to factory floor—are another 70,000 people in 22 industries, represented by 17 prime contractors, 200 subcontractors, and more than 200,000 suppliers. Our program, in addition, has entailed the recruitment of a substantial slice of talent in military management — about 500 officers chosen for technical competence and for their healthy disrespect for red tape."

Evidence of the practical value of the "altogether and all-at-once" management was provided by the first flight of the Thor missile. Eleven months after Dept. of Defense approval was granted, the first Thor missile came off the production line. The Air Force has

Atom Angles

Nuclear space vehicles to be built by the Atomic Energy Commission are proposed in a bill sponsored in the Senate by Sen. Clinton P. Anderson, (D., N.M.). The bill would permit the AEC to add to its current responsibilities the necessary research, construction and operating facilities with which to achieve peaceful control of outer space and interplanetary travel. An appropriation of $50 million is proposed to finance initial operations and construction.

• • •

Possibly severe limitations on the development of atomic energy for peacetime uses were aired in a recent report of an inquiry into the feasibility of underground disposal of radioactive waste from atomic energy installations. The National Academy of Sciences—National Research Council, under contract with the AEC, reported no specific answer to "How shall we dispose of radioactive waste?" Members question long-term safety of waste disposal as practiced at present atomic installations.

• • •

Model C Stellarator will be designed and built for advanced research into controlled thermonuclear reactions. A joint engineering staff known as C Stellarator Associates has been established by Allis-Chalmers and RCA. The selection of the two companies to carry out the project was announced recently by Princeton University and the AEC. The C Stellarator, to be located at the University's James Forrestal Research Center in Princeton, is scheduled for completion in 1960.

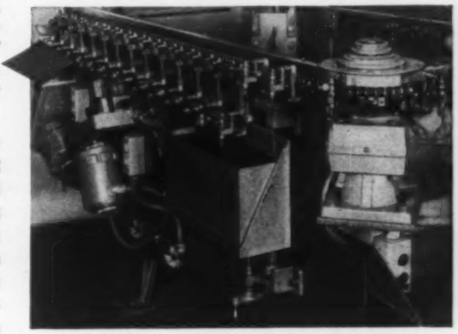
every confidence, he said, that by December of 1958, just 36 months after the inception of the Thor project, a completely operational Thor squadron will be ready for overseas deployment.

Looking ahead, Gen. Schriever said, "We will have to keep refining and improving our first comparatively primitive ballistic missiles, which are now, in effect, Model-T versions. We will have to produce them at less cost. We will

(Please turn to Page 44)

DIAMOND NEWS ABOUT ROLLER CHAIN DRIVES, APPLICATIONS AND NEW PRODUCTS.

Machinery designers use stock Diamond Roller Chain and attachments . . . gain dependability, availability and low costs



The Eraser Company of Syracuse, N. Y., designed this machine to strip insulation, flux, tin, wipe off excess solder, eject and lay down finished Fuse Plugs at a rate of over 2000 per hour.

William Wentworth and Vic Goyer, Chief Engineer and Project Engineer, selected stock Diamond No. 60, ¾-inch pitch Roller Chain; four No. 60, 35-tooth sprockets; and stock attachment link plates to carry the plug holders. The chain moves at 13 feet per minute and requires a driving torque of 30 ft. lbs.

Use of standard Catalogued Diamond Chains and Sprockets reduced design time and costs, assures a readily available supply whenever required at lowest possible cost. Dimensions, weight, tensile strength and all service capabilities are proven.

Advantages are as great for *users* of machinery designed largely around catalogued items. Dependability, long life and low maintenance are assured. Replacements, if ever required, are available immediately through stocking Diamond Distributors in all principal cities.

STOCK DIAMOND PARTS USED

Diamond No. 60 Roller Chain ¾" pitch.

One side of chain:
Bent Attachment Roller Link Plates No. B-1-RL.
Bent Attachment Pin Link Plates No. B-1-CL.

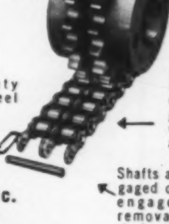
Opposite side of chain:
Bent Attachment Roller Link Plates No. B-1-RL.
Straight Attachment Link Plates No. S-1-CL.

Four No. 60C35-35 tooth Diamond Sprockets.

New Catalog 757 contains 68 pages of valuable information for machinery designers. Tables and charts give you the data needed to select stock Diamond Roller Chain, sprockets and attachments for your applications. For answers to special drive problems, write to the Diamond Engineering Department. Their specialized application experience will save you time and money.

NEW TAPER-BUSHED FLEXIBLE SHAFT COUPLINGS

These new Diamond couplings feature a short overall length plus interchangeable taper-bushings that make them ideal for use where both shaft extensions are short. Shafts need not be of the same diameter. Stock Taper-Bushings vary by 1/16" increments through a wide range of shaft sizes. Casings are available to seal in lubrication and seal out dust and corrosive atmospheres. Standard Finished Bore Diamond Couplings are available for fractional to 725 horsepower applications.


Coupling halves are made for bushing insertion from hub or flange end.
Precision Diamond coupling sprockets.
Heavy duty spring-steel lock.
Double strand Diamond Roller Chain gives great capacity with small overall diameter.
Shafts are engaged or disengaged by removal of a single pin.

DIAMOND CHAIN COMPANY, Inc.
A Subsidiary of American Steel Foundries
Dept. 435, 402 Kentucky Ave., Indianapolis 7, Indiana
Offices and Distributors in All Principal Cities

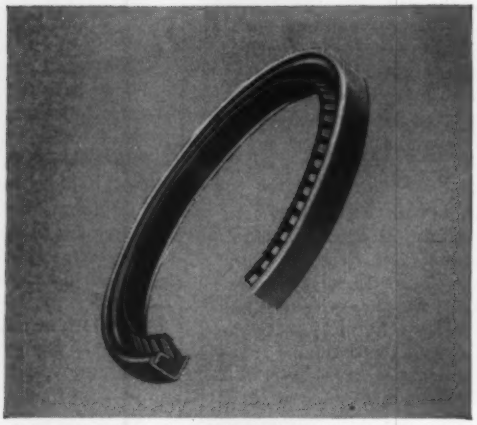
Write for New Catalog 757

DIAMOND ROLLER CHAINS

Circle 421 on Page 19

How design engineers 4 Garlock

"... bearing seals must keep lubricants *in* and dirt *out*. The best seals are the ones that can do this efficiently with minimum friction throughout long service periods. Garlock's KLOZURE** Oil Seals meet all these qualifications. Moreover, they're available in over 3000 stock sizes!"



Cross section shows Garlock KLOZURE Oil Seal Model 53 for normal and high-speed service.

"... there's a neat trick to making silicone sponge rubber. Garlock makes it so that it provides maximum design advantages—flexibility at −100° F., heat resistance at +500° F., shedding of water or ice, abrasion and tear resistance . . . ideal stuff for use around airframe or appliance openings."

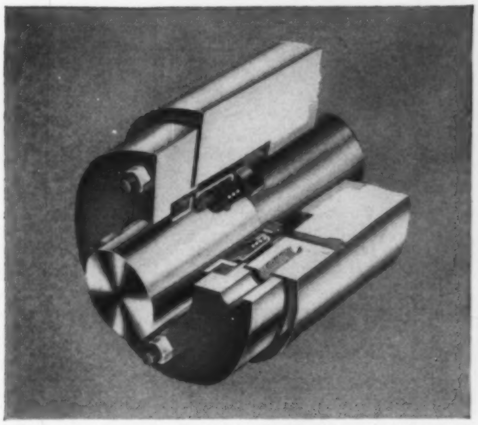
Garlock Silicone Sponge Rubber has millions of non-connecting cells which provide natural insulation. Temperature range −100 to +500° F.

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals,
Molded and Extruded Rubber, Plastic Products

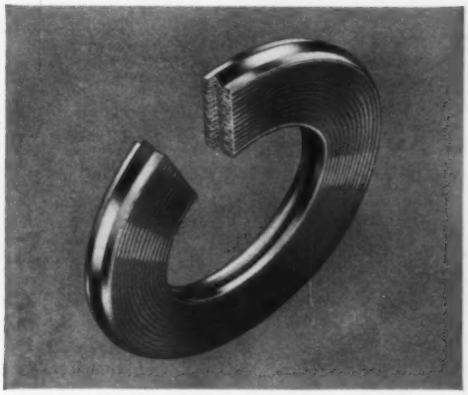
speak about these products

"... of course, the ultimate in sealing today is the mechanical seal. In many applications Garlock's Mechanipak** Seals operate indefinitely. Difficult sealing jobs, however, are the real test of a mechanical seal—and Mechanipaks have provided a long and still growing list of successful applications against water, oils, alcohol, mild acids, and solvents. By making use of Teflon,* Garlock has also developed a Chemiseal** mechanical seal with the greatest immunity to corrosion and contamination."



Garlock MECHANIPAK Seal. Write for Catalog AD-150 and AD-164.

"... Garlock Spiral Wound Guardian** Gaskets are designed for various pressure ranges under established bolt loads. This is done by increasing or decreasing the number of layers, or windings, of stainless steel and Teflon (or asbestos). Thus, a safe seal is obtained at highest pressures.



Garlock Spiral Wound GUARDIAN Gasket. Write for Catalog AD-104.

These products are another important part of the Garlock 2,000 . . . two thousand styles of Packings, Gaskets, and Seals for every need. The only complete line. It's one reason you get unbiased recommendations from your Garlock representative. Call him or write for literature.

THE GARLOCK PACKING COMPANY,
PALMYRA, N.Y.

For Prompt Service contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.

*DuPont Company Trademark
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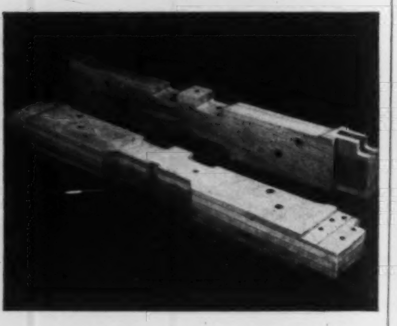
Circle 422 on Page 19

WHAT'S YOUR
WOOD
PROBLEM?

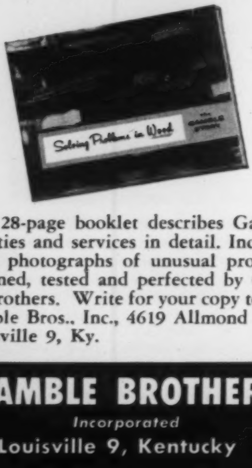


Believe it or not—
Gamble research even
improves subway cars!

THE PROBLEM . . . A subway car manufacturer was having trouble with the contact shoe beams on cars. The solid wood beams (which hold the apparatus for picking up power from the third rail) were proving a headache because of too-high moisture content and too-low dielectric strength.

THE RESULT of Gamble development and testing: a laminated hard maple beam that is thoroughly dry, possesses high dielectric strength and holds perfectly to dimensional tolerances. Perhaps Gamble could help with *your* wood problem.

Send for FREE booklet
Illustrating GAMBLE services



This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Bros., Inc., 4619 Allmond Ave., Louisville 9, Ky.

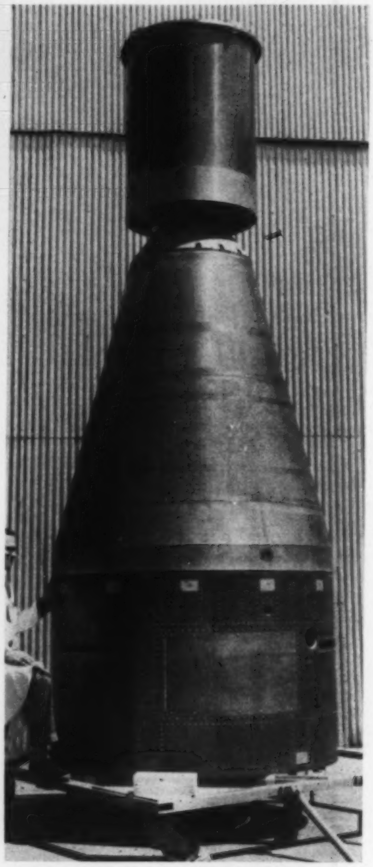
GAMBLE BROTHERS
Incorporated
Louisville 9, Kentucky

*If the problem involves WOOD
—GAMBLE can help!*

Circle 423 on Page 19

(*Continued from Page* 41)

have to make them more accurate, more reliable, less complicated. We are now making these decisions to attain these results—and at the same time we must make further decisions to design, develop, and produce this next generation of missiles.



BALLISTIC SPIN for second and third stages of Jupiter-C missile is provided by the bucket-like spin-launcher mounted on nose of the first stage Redstone. Second stage, a cluster of 11, 50-in. Wac Sergeant rockets, and third stage, a cluster of 3 Sergeants, are mounted inside the spin-launcher. Immediately after firing of the first stage Redstone, a "gear arrangement" begins spinning the launcher at an increasing rate of speed until the second stage is triggered. To launch satellite, a fourth stage is added—one Wac Sergeant with satellite attached. Spin launcher and Redstone airframe are constructed of aluminum by Reynolds Metals Co.

Paint Resists 1000 F Thermal Shock Without Damage

CHICAGO—Made of graphite and silicones, a new paint is capable of withstanding violent thermal shock of 1000 F range. Developed by the Joseph Dixon Crucible Co., the paint, called Thermocone, is the first graphite silicone coating ever developed. It is intended for special maintenance applications in the steel, chemical, and natural gas industries.

The efficiency of the new paint has been demonstrated under extraordinary test conditions by heating metal disks, painted with Thermocone, to a temperature of 1000 F and plunging them into beakers of icy water. The shock does not cause the paint to crack, peel, flake, or bubble.

Meetings

AND EXPOSITIONS

March 11-14—

Pressed Metal Institute. Spring Technical Meeting to be held at the Sheraton-Cadillac Hotel, Detroit. Further information is available from PMI headquarters, 3673 Lee Rd., Cleveland 20, Ohio.

March 17-18—

Steel Founders' Society of America. 56th Annual Meeting to be held at the Drake Hotel, Chicago. Additional information is available from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

March 17-20—

American Society of Mechanical Engineers. Aviation Div. Conference to be held at the Statler-Hilton Hotel, Dallas. Additional information can be obtained from ASME headquarters, 29 West 39th St., New York 18, N. Y.

March 17-21—

National Association of Corrosion Engineers. Fourteenth Annual Conference and Exhibition to be held at the Civic Auditorium, San Francisco. Further information is available from association headquarters, 1061 M & M Bldg., Houston 2, Tex.

March 17-21—
1958 Nuclear Congress, to be held in conjunction with the Atomfair of the Atomic Industrial Forum at the International Amphitheatre, Chicago. More than 30 organizations sponsor the Congress, which is co-ordinated by the Engineers Joint Council, 29 W. 39th St., New York 18, N. Y.

March 19-20—
American Society of Mechanical Engineers. Engineering Management Conference to be held at the Somerset Hotel, Boston. Further information is available from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

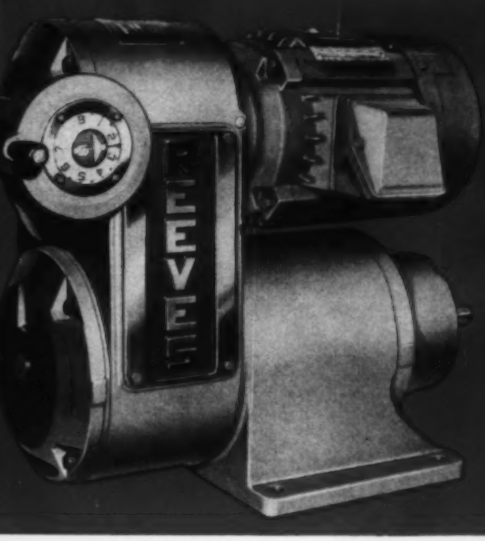
March 24-27—
Institute of Radio Engineers. National Convention to be held at the Waldorf-Astoria Hotel and the Coliseum, New York. Additional information can be obtained from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

March 26-28—
20th Annual American Power Conference to be held at the Hotel Sherman, Chicago. Conference is sponsored by Illinois Institute of Technology in co-operation with 14 other colleges and universities and nine technical societies. Additional information can be obtained from Dr. E. R. Whitehead, Electrical Engineering Dept., Illinois Institute of Technology, Chicago 16, Ill.

March 31-April 2—
Society of Automotive Engineers. Production Meeting and Forum to be held at the Drake Hotel, Chicago. Further information is available from society headquarters, 485 Lexington Ave., New York 17, N. Y.

April 1-3—
American Society of Mechanical Engineers. Instruments and Regulators Conference to be held at the University of Delaware, Newark, Del. Further information can be obtained from ASME headquar-

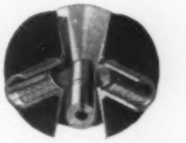
corrosion-proof
variable speed



REEVES® *Vari-Speed MOTODRIVE*

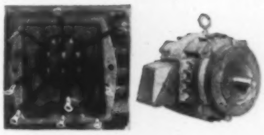
● A complete variable speed power package for the equipment you design for use in highly corrosive atmospheres.

Available from ¼ through 5 hp., the 100, 200 and 300 size Motodrives are resistant to most acids, gasses and corrosive dusts. They feature a wide speed range . . . up to 10:1 with gear ratios from 1.17:1 to 195:1 . . . and provide infinitely variable speeds in hundreds of standard assemblies to fit nearly any space requirement.



Corrosion-Proof Disc Assemblies
Corrosion resistant cast iron; Exclusive REEVES "close grooving"—for positive disc lubrication.

Corrosion-Proof Gear Reducers
Cast iron gearbox and head; shaft oil seal—double tip neoprene; leak proof vent plug.



Corrosion-Proof Motor
Solid cast iron housing and fan—fully sealed cast iron conduit box—motor lead gasket seals off motor windings.

Fully sealed cast iron Motodrive case and inspection plates protect operating internals—lifetime stainless steel nameplates and identification plates—zinc plated Hexhead capscrews throughout. Write for Bulletin H34-M578.

REEVES PULLEY COMPANY
Division of **RELIANCE** ELECTRIC AND ENGINEERING CO.
Columbus, Indiana

Circle 424 on Page 19

P&B PROGRESS/

UNIQUE DESIGN IMPROVES WEIGHT, SIZE, PERFORMANCE FACTORS

NEW!

Miniature telephone type relay has superior shock/vibration resistance

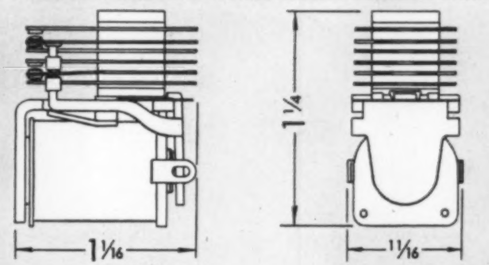
NEW
POTTER & BRUMFIELD
MG SERIES RELAY

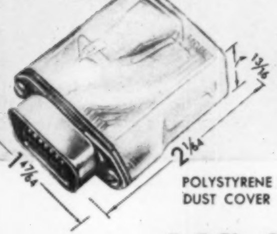
Unusual for a telephone type relay, the MG Series has excellent stability under high shock and vibration conditions. Tests show this miniature, light weight (only 1.2 oz., open) relay withstands vibration of 10g 55 to 500 cycles per second and will operate under shock to 30g according to Mil-R-5757C.

The superior performance of the MG is due in part to its unique single stack construction and to an exclusive hinge design which provides zero heel gap.

Open, dust covered or hermetically sealed, the MG is available with contact arrangements up to 4 Form C (4PDT). It is rated for ambient temperatures of −55°C to +85°C. A high-temperature version with a range of −65°C to + 125°C will soon be available. Write or wire today for complete specifications and delivery.

POTTER & BRUMFIELD, INC., PRINCETON, INDIANA—SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY





POTTER & BRUMFIELD PRINCETON, IND.

POLYSTYRENE
DUST COVER

HERMETICALLY SEALED

MG SERIES

TERMINALS:
Open Relay: Pierced Solder Lugs.
Contacts: Two #18 AWG wires. Coil: Two #20 AWG wires.
Hermetically Sealed:
Miniature plug-in header with 7, 9 or 14 pins. Multiple Solder header with hook end terminals for three #20 AWG wires.
Polystyrene Dust Cover: Micro Ribbon plug-in type.
Mating receptacle: Amphenol #57-20140 or similar.
INSULATION RESISTANCE: 100 megohms min.
VIBRATION: .065" excursion 10-55 cps.
10g 55-500 cps. upon request.
SHOCK: 30g according to Mil-R-5757C upon request.
TEMPERATURE RANGE: −55°C to +85°C.
WEIGHT: 1.2 ozs. (open) 2.0 ozs. (sealed).
PULL-IN SPEED: Approximately 15 ms at nominal voltage.
DROP-OUT SPEED: Approximately 10 ms at nominal voltage.
CONTACTS: 3/32 silver.
CONTACT ARRANGEMENT: 4 pole, double throw (4 Form C).
COIL POWER: 3 watts max. DC @ 25°C. Continuous duty.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC, ELECTRICAL AND REFRIGERATION DISTRIBUTORS
See our catalog in Sweet's Product Design File.

Potter & Brumfield, inc.
PRINCETON, INDIANA

SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY
Manufacturing Divisions also in Franklin, Ky. and Laconia, N. H.

Mail the coupon below for further engineering data on P&B's MG Relay *plus* new compact catalog of standard type relays. If you need answers to a specific application problem, write in detail.

Potter & Brumfield, Inc., Princeton, Indiana
Attn: T. B. White, Brig. Gen. USMC (Ret.)
Special Projects Engineer
Please send me complete engineering data on the MG Relay plus the new compact catalog of P&B standard relays.
Name__________
Company__________
Address__________
City__________ Zone_____ State__________

Circle 425 on Page 19

ters, 29 W. 39th St., New York 18, N. Y.

April 8-11—
Society of Automotive Engineers. Aeronautic Meeting, Aeronautic Production Forum and Aircraft Engineering Display to be held at the Hotel Commodore, New York. More information can be obtained from society headquarters, 485 Lexington Ave., New York 17, N. Y.

April 14-17—
Design Engineering Show to be held at the International Amphitheatre, Chicago. Design Engineering Conference, sponsored by the Machine Design Div. of ASME, will be held in conjunction with the show. Additional information is available from Clapp & Poliak, 341 Madison Ave., New York 17, N. Y.

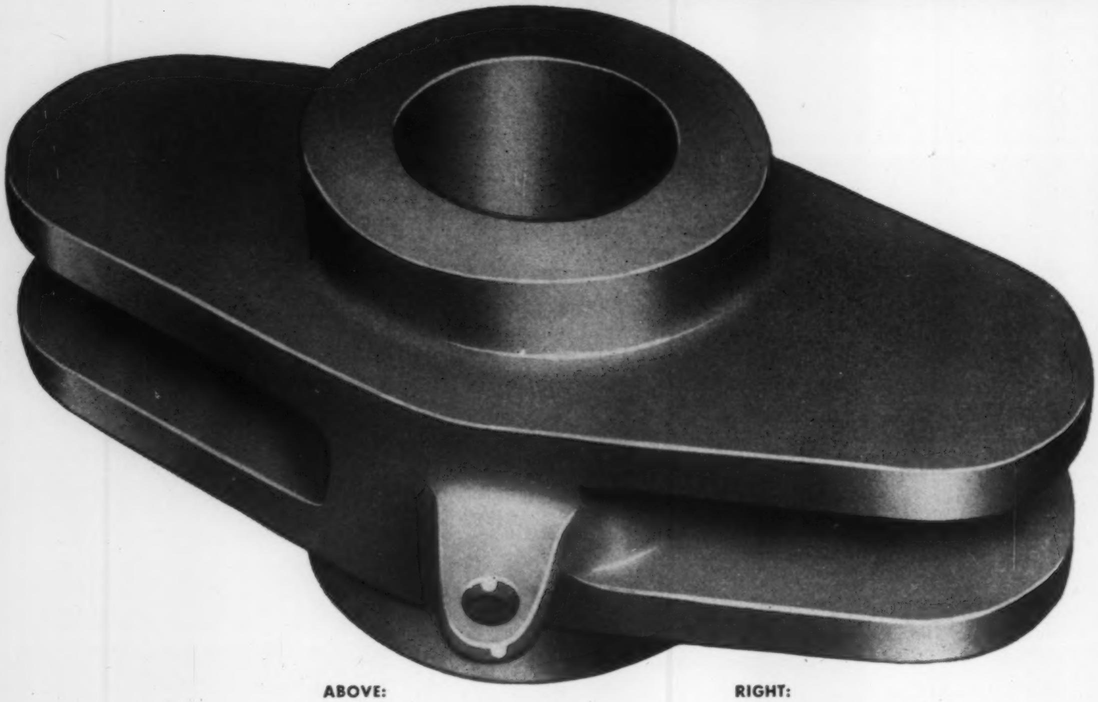
April 14-18—
American Welding Society. National Spring Meeting to be held in St. Louis. The show will be held at Kiel Auditorium April 15-17; technical sessions will be presented at Hotel Statler April 14-18. Further information can be obtained from AWS headquarters, 33 W. 39th St., New York 18, N. Y.

April 20-24—
Scientific Apparatus Makers Association. 40th Annual Meeting to be held at the El Mirador Hotel, Palm Springs, Calif. Additional information is available from association headquarters, 20 N. Wacker Dr., Chicago 6, Ill.

MACHINE DESIGN
scheffy

BEFORE YOU SAY . . .

"IT CAN'T BE CAST"



ABOVE:

Automatic Winch brake pawl carrier.

Previous cast weldment required costly machining. *ESCO* Shellcasting eliminated major machining and effected considerable savings.

RIGHT:

Transmission Shifter Fork.

As formerly cast the fork tip pads posed difficult alignment problems during machining. *ESCO* Shellcast made possible the casting of the fork tip pads to size and in alignment, eliminated machining, reduced the unit price.

CALL AN ESCO ENGINEER

ESCO alloy steel castings can make your designing *easier.* You get the part you want, in the alloy you need and in the shape that saves you the most fabricating, machining and finishing time.

PLUS METALLURGICAL ENGINEERING AND RESEARCH

ESCO maintains one of the largest and best equipped metallurgical staffs of any alloy steel foundry —

PLUS PRODUCT ENGINEERING AND DESIGN

An integrated service at all levels; in the field, at the drawing board and in the foundry —

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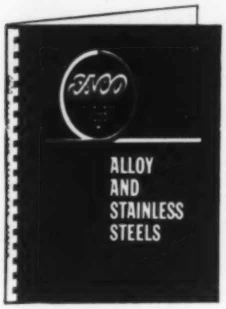
A casting service that covers the complete range of alloy steel casting methods of all applications —

PLUS LABORATORY INSPECTION AND TESTING

ESCO laboratory technicians are qualified and equipped to perform all types of inspections and testing to the most rigid specifications.



Write today for your FREE copy of this informative 100-page reference book, "ESCO Alloy and Stainless Steels for the Process and Manufacturing Industries"

Call an *ESCO* Engineer—let him show you how *ESCO* Alloy Steel Castings make your designing easier.

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Offices in Most Principal Cities
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Circle 426 on Page 19

NOW—PRECISION GEAR GRINDING at phillie gear

Single point grinding method eliminates burning or cracking of tooth surface

...assures the ultimate in hardened gear accuracy, practically silent operation

Long years of experience have clearly shown that ground tooth gears can transmit higher loads than gears manufactured by conventional methods. Precision gearing properly hardened and ground can be reduced 60% in size, while service life is increased.

Phillie Gear has now installed the latest gear grinding equipment for spur and helical gearing up to 26″ diameter, with tip root relief and crowning available. Similarly, spiral bevel, zerol, and hypoid gearing can be precision ground up to 23″ diameter.

For an engineered recommendation, send your precision gearing problems to Philadelphia Gear Works.

phillie gear®

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ERIE AVE. & G STREET, PHILADELPHIA 34, PENNA.
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INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS

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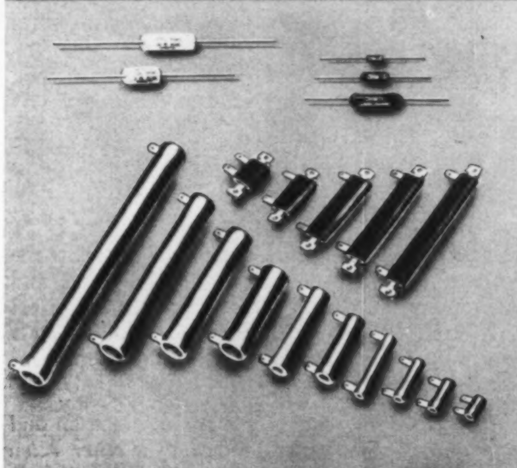
OHMITE®

OFFERS THE COMPLETE LINE OF RHEOSTATS AND RESISTORS TO MEET MILITARY SPECIFICATIONS

RHEOSTATS: MIL-R-22A

Ohmite can furnish rheostats in *every* one of the 26 type designations to meet the requirements of MIL-R-22A. By standardizing on Ohmite rheostats, you can cover all of your needs for both civilian and government jobs and, at the same time, give your customers the utmost in rheostat performance. Ohmite rheostats have proved their dependability in meeting the severe requirements of MIL-R-22A . . . the 5-hour vibration test, 50-hour salt-spray corrosion test, 150-hour 95% humidity electrolysis test . . . and others.



ALL CHARACTERISTICS · ALL SIZES ALL RESISTANCE VALUES

Their all-ceramic construction . . . uniform windings locked in place by vitreous enamel . . . smoothly gliding, metal-graphite brush insure close control and years of trouble-free service.

Also, Aircraft Rheostats produced in accordance with Specification MIL-R-6749 (Drawing AN-3155).

RESISTORS: MIL-R-26C Characteristics

Y High Temperature 350° C Characteristic High Insulation Resistance

V High Temperature 350° C Characteristic

AND **G**

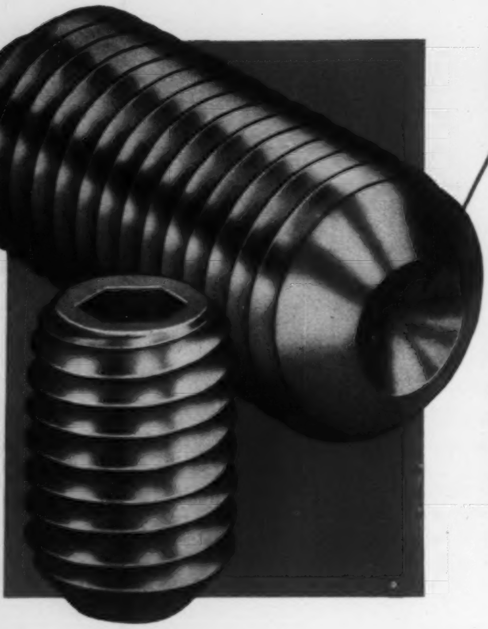
Ohmite resistor types can withstand a continuous operating temperature of 350° C—the high temperature requirement of MIL-R-26C, Char. "V." These resistors also meet Characteristic "G." The new Char. "Y" combines all requirements of Char. "V" and "G" plus extremely high insulation resistance at the end of the moisture-resistance test. Under all three Char., "V," "Y," and "G," Ohmite resistors have to satisfy severe moisture-resistance tests, thermal shock tests, vibration tests, and many others. Units feature patented, all-welded construction.

OHMITE®
QUALITY Components

WRITE FOR MIL BULLETIN 139

RHEOSTATS · RESISTORS · RELAYS ·
TAP SWITCHES · TANTALUM CAPACITORS ·
VARIABLE TRANSFORMERS

OHMITE MANUFACTURING COMPANY
3618 Howard Street, Skokie, Illinois



ALLENPOINT will give you a bulldog grip at no premium in price!

Allen's scientific redesign of the cup diameter on set screws gives greatly increased resistance to *withdrawal* torque. You can count on Allenpoint Set Screws to stay tighter longer, under heavy strain and vibrations. This dependable premium performance of Allenpoints is yours to use without increasing the cost of manufacturing your products.

Uniform Class 3A Threads

Allenpoints' smooth, uniform threads prevent off-lead conditions like Fig. 1. With Allenpoints, you have full, even contact between the engaging flanks of the threaded members (Fig. 2) —and a tight friction lock over the entire length of the Allenpoint Set Screw.

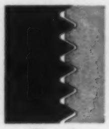


Fig. 1

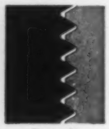
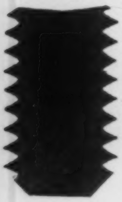


Fig. 2

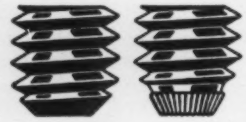
Strong, clean, deep sockets allow full wrenching leverage



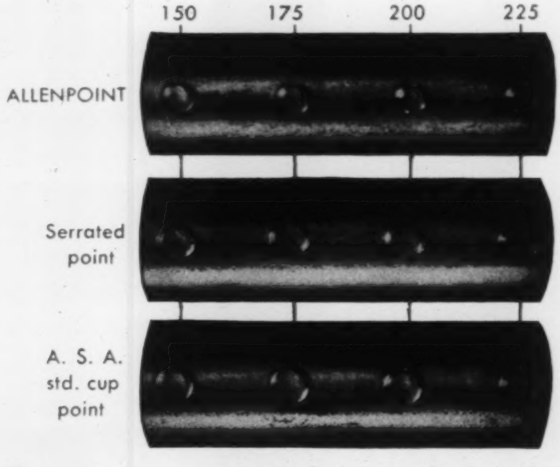
Sockets of Allenpoint Set Screws are cold forged to produce a deeper, smoother socket. No broach chips to interfere with proper seating of the key. This "pressur-forming" preserves the long steel fibers throughout the length of the screw—stronger walls allow maximum tightening torque.

One more full thread on ALLENPOINTS!

Allenpoint Set Screws have one more full thread than serrated point set screws. That means more holding power—especially important when you're using short lengths.



ALLENPOINT's performance compared for you



These actual-size, unretouched photographs show the cup pattern made by Allenpoints, serrated points, and A.S.A. standard cup point set screws in a 3/4" steel shaft. At each degree of tightening force, Allenpoints make a full circle pattern, penetrating deeper for greater holding power.

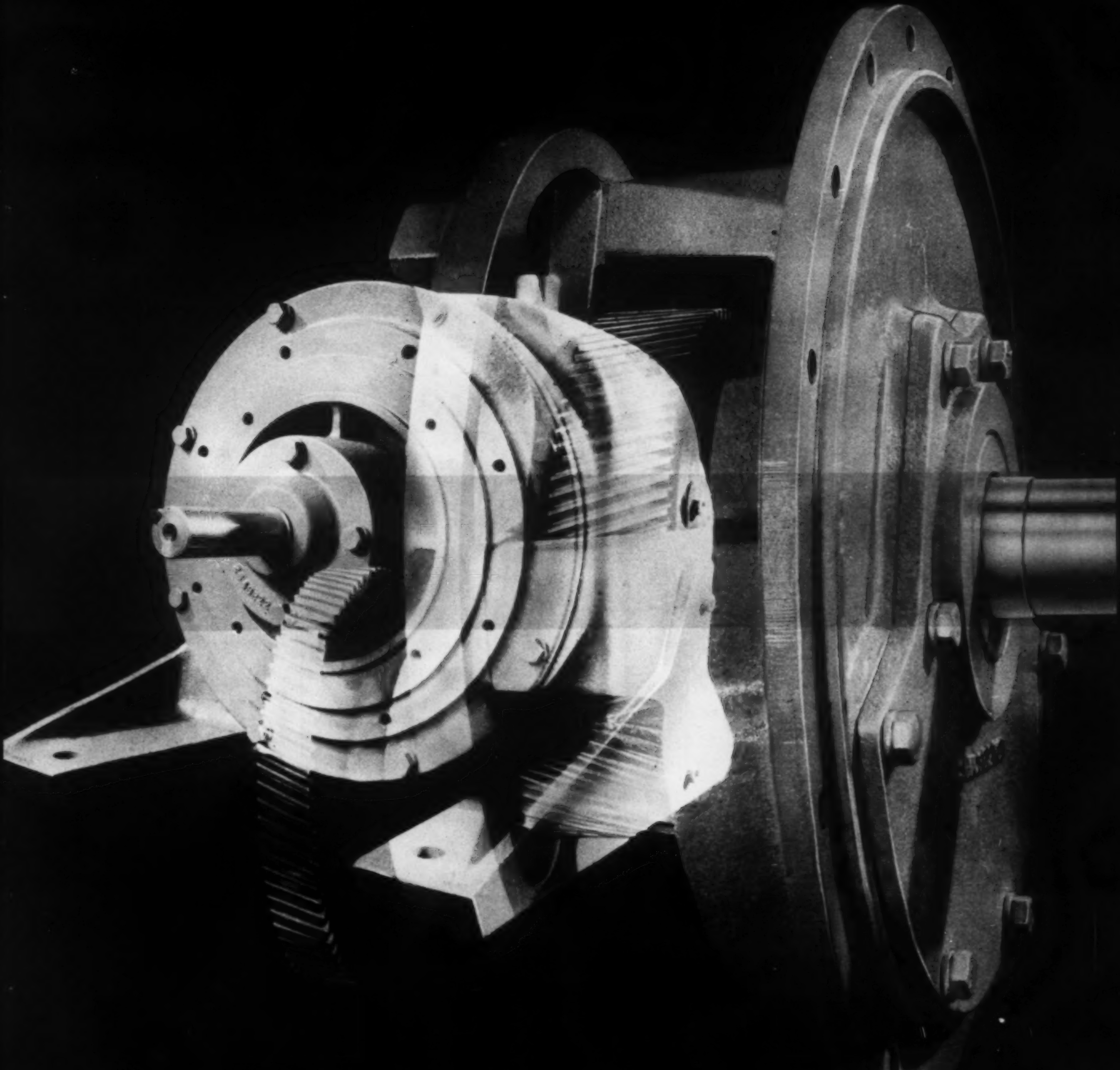
We'll be glad to send you more information and samples of Allenpoint Set Screws and other Allen Socket Screw products.

Stocked and sold by leading industrial distributors everywhere

ALLEN MANUFACTURING COMPANY
Hartford 2, Connecticut, U. S. A.

ALLEN HEX-SOCKET SCREWS HEAD

EXCLUSIVE DEVELOPMENT OF WESTINGHOUSE ELECTRIC CORPORATION

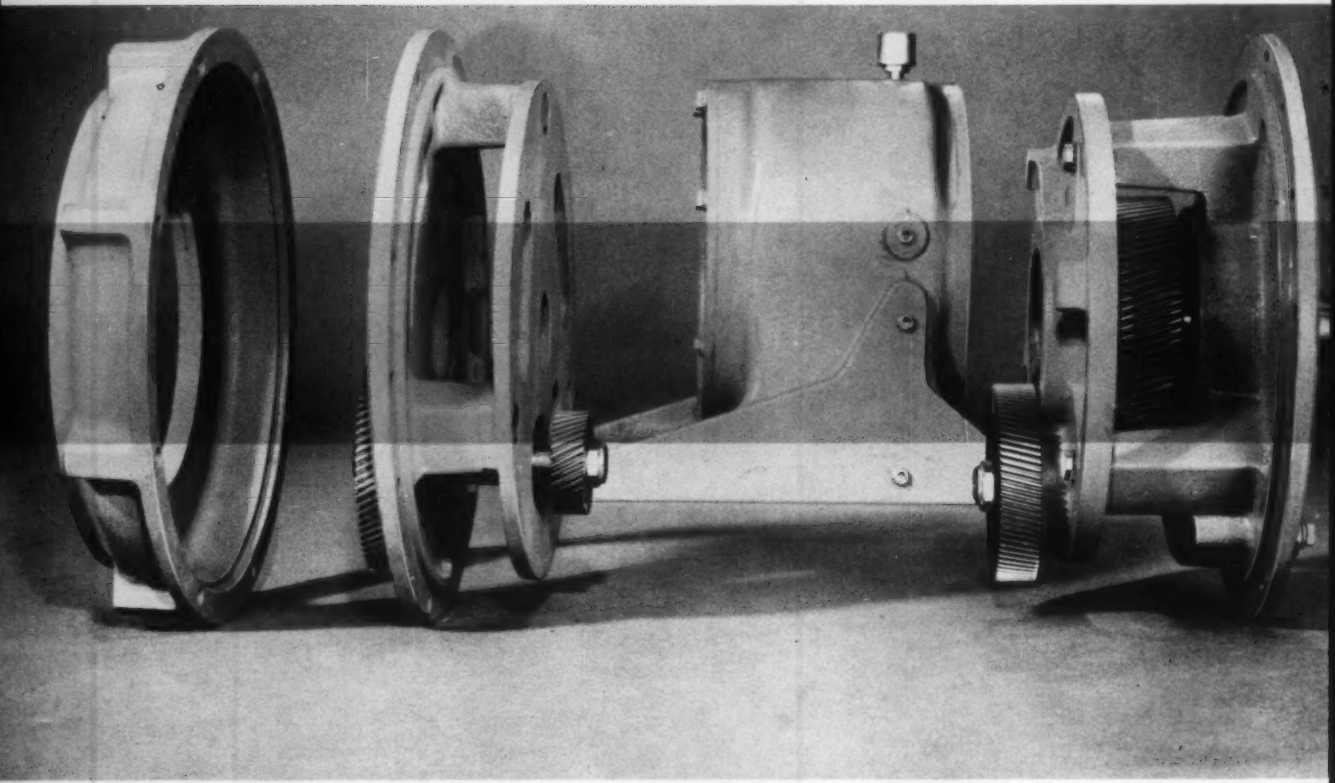


NEW MODULINE GEAR UNITS

OFFER YOU ORIGINAL ADVANTAGES IN
SIMPLICITY • VERSATILITY • DEPENDABILITY

MODULINE

IS ORIGINAL IN SIMPLICITY... IN VERSATILITY



Basic Moduline components combine to form double, triple or quadruple reduction speed reducers, gearmotors or package motor reducer drives with gear ratios from 4.17:1 to 985.3:1.

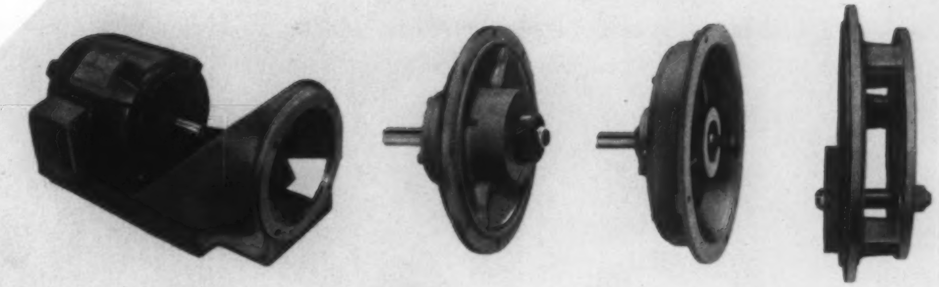
These preassembled modules standardize over 20,000 variations of gearmotors, speed reducers and package motor reducer drives

Look over the simplicity, dependability and versatility you get from Westinghouse Moduline gear units. Here you'll find original answers to solve long-standing problems in application of gearmotors and package motor reducer drives from 1 to 30 hp; foot-mounted speed reducers from 1 to 75 hp; and shaft-mounted speed reducers from 1 to 40 hp, including concentric shaft and right angle configurations.

What's more, just seven Moduline frame sizes cover these broad ranges. By ordering Moduline drives, together with any type of Westinghouse Life-Line® motors, you combine two purchases in one order with complete assurance of design and application coordination.

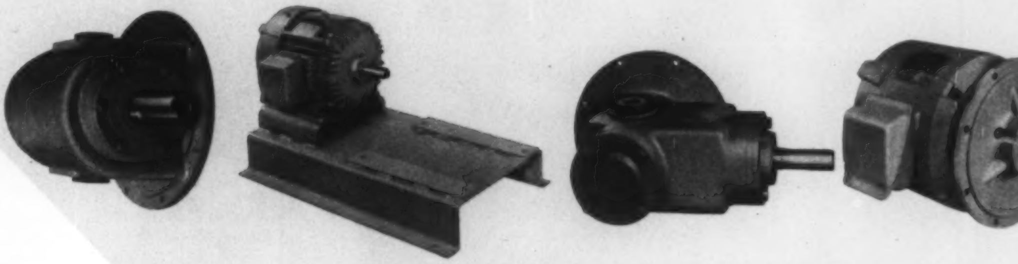
J1-07368-2

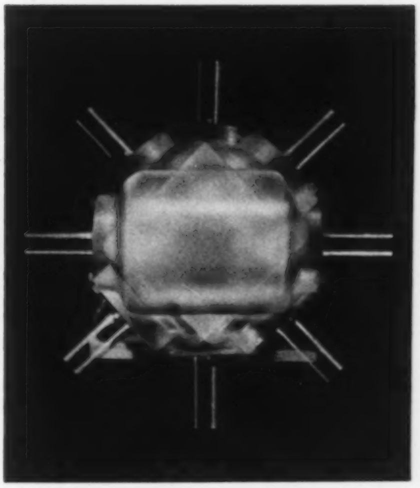
EXCLUSIVE DEVELOPMENT OF



Moduline originality offers application and maintenance savings

Here are subassemblies for the most versatile gear drives on the market. From these modules . . . concentric shaft or right angle . . . integral gearmotors, package motor reducer drives and speed reducers can be assembled exactly to your specifications. Motor support brackets, right angle heads (in fact, all Moduline parts) go together in thousands of different ways to make the right drive for any job.

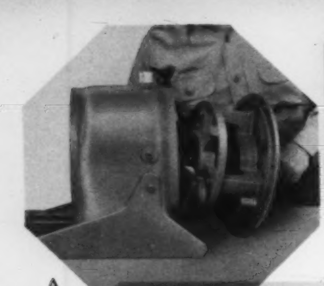


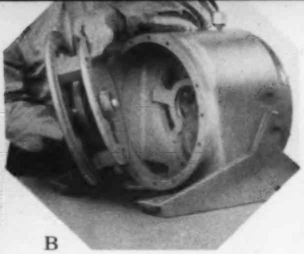


Moduline units can be installed in any location. Concentric shaft units can be mounted in any position on the floor, wall or ceiling . . . or at any angle in between. The output shafts of right angle units can be indexed in 8 or 12 positions for power take-off in almost any direction. Units are designed for electric motor or engine drive; chains, belts or gears may be used to put power into or take it out of them. Only Westinghouse offers Moduline units with right angle input or output assemblies. These 1 to 75 hp reducers with ratios from 7.6:1 to 985.3:1 can handle any job.

JI-07368-3

WESTINGHOUSE ELECTRIC CORPORATION


A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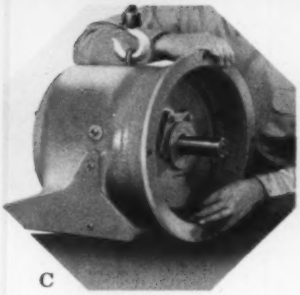
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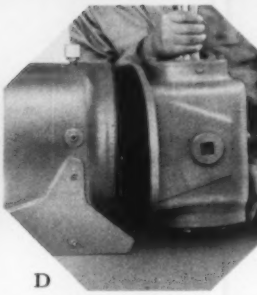
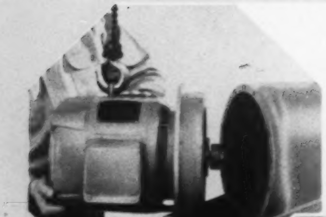
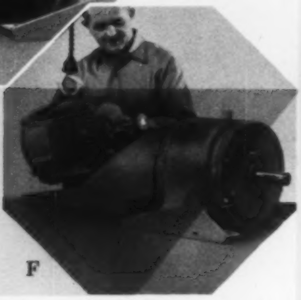
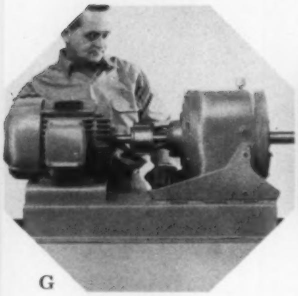
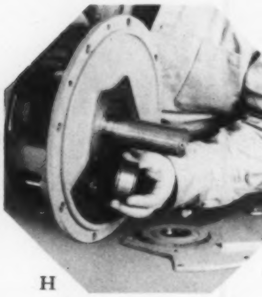

D

For *speed reducer* assemblies (above), reducer case and low speed cage assembly with 5:1 gear ratio combine with high speed change pinion and gear set (A) which are available i nine standard ratios from 1:1 to 5:1 and for double reduction up to 25:1. For triple and quadruple reductions, add chang gear set and high-speed cage assembly (B) . . . with either 5:1 or a 25:1 ratio . . . for total ratios up to 625:1. For *vertica mounting*, add flange and face-type seal (C). For *right angl* output units, add head assembly (D).


E


F


G


H

Gearmotors and package motor reducer drives are assembled wit AGMA standard flange-mounted motor (E) or NEMA standar foot-mounted motor, with either "sugar scoop" motor suppor (F) or combination bedplate (G). Backstop kit (H) can b added to any unit.

A standard wrench assembles or modifies any Moduline unit

Only a wrench is needed to work on Moduline units. Awkward gear pullers and troublesome fitting have been eliminated. It's another example of the original advantages you gain from Moduline design and quality.

Unusual manufacturing processes, preassembly and pilot fits make modular construction possible. All parts are accurately machined within very close tolerances. No checking, aligning or positioning of modules is necessary during assembly.

Moduline shafts are roll-formed to provide splined and threaded extensions for simple gear mountings. Pinions and gears have splined bores for ease of assembly. An elastic stop nut locks them in position.

JI-07368-4

WESTINGHOUSE

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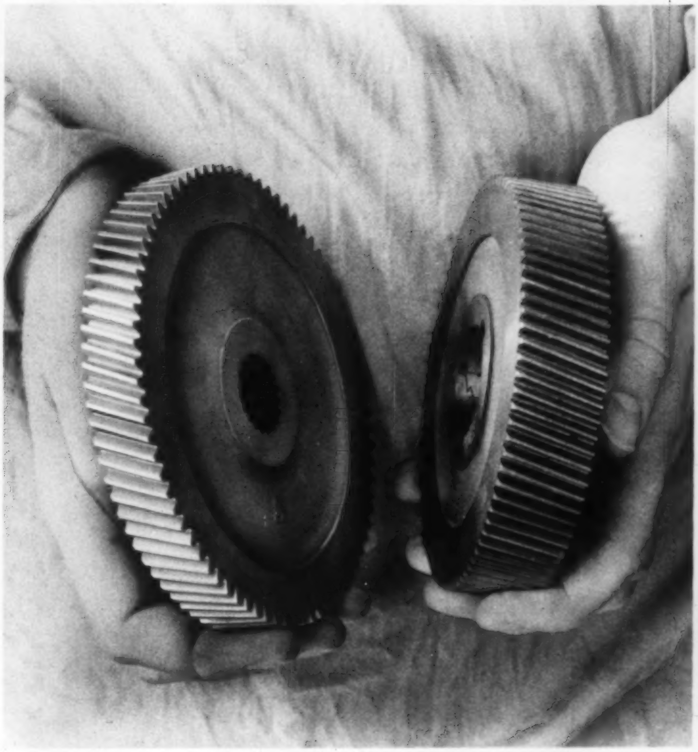
MODULINE

IS ORIGINAL IN DEPENDABILITY

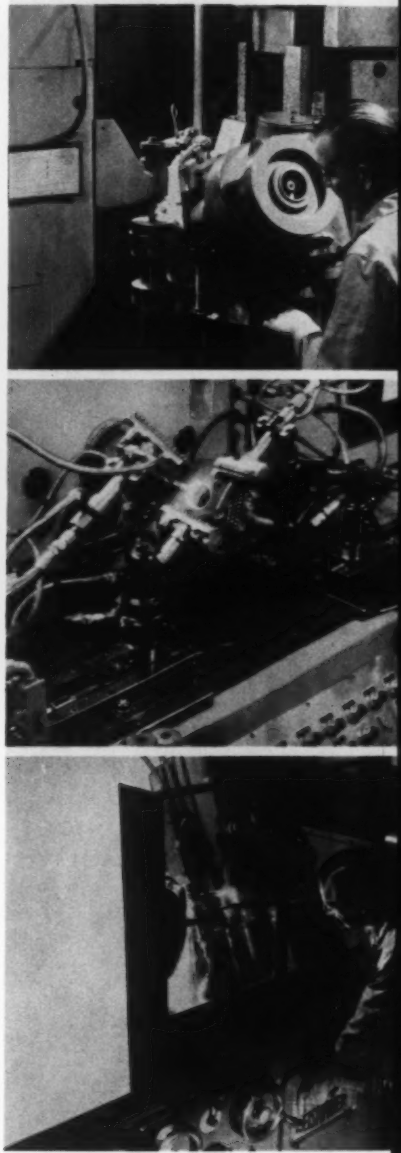


Compare the Moduline ground tooth gear (left) with conventional gear. Note smooth finish, splined bore and drop-forge blank that's standard with all Moduline gears.

Only MODULINE combines ground "master gear" precision with tough, wear and shock-resistant alloy steels

See the difference between a conventional gear and a Moduline precision-ground, heat-treated gear. Moduline gear teeth are so accurate they meet AGMA master gear requirements for pin dimensions, pitch error, profile error and lead error. This means unusual dependability with quiet, efficient operation. Previously, you would have to special-order and pay a premium for the quality now made standard by Moduline. These precision gears have low sound levels and increased mechanical capacity. Spin-flame heat treatment and tempering produce hard, wear-resistant surfaces backed up by tough-hardened cores to stand up under all kinds of service.

JI-07368-5



(*top*) Precision hobbing cuts Moduline gear teeth on alloy steel blanks

(*middle*) Through-hardening on automatic spin-flame equipment for extra wear resistance

(*lower*) Finish grinding to master gear standards

MODULINE

delivery is fast because it's "built in"

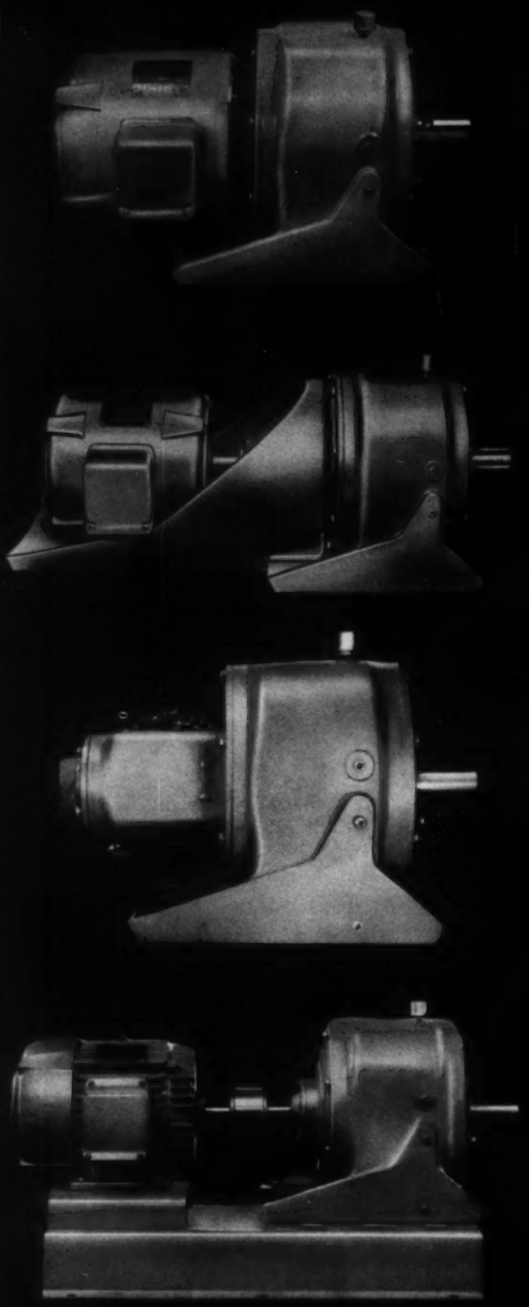
Original modular design and complete standardization of components simplifies specification, inventory control and gives fast deliveries from local Westinghouse warehouses.

Your local Westinghouse sales office fills your order from a nearby warehouse. Moduline drives are shipped completely assembled to your instructions, ready to go to work. All Moduline warehouses also carry complete stocks of renewal parts and subassemblies for the maintenance or modification of customer units. Fast parts deliveries and serviceability of Moduline designs reduce down time and maintenance costs to a minimum. A small inventory backs up many units for customers who prefer to stock their own parts and subassemblies.

...see MODULINE facts in action

A desk-top demonstration of Moduline scale models is the first step to lower gear drive costs. Your Westinghouse sales representative will arrange a demonstration; or write Westinghouse Electric Corporation, Gearing Division, 200 McCandless Ave., Pittsburgh 1, Pa.

J1-07368-6



POWER-UP with MODULINE

a complete line of . . .
speed reducers . . . gearmotors . . .
and motor reducer drives

YOU CAN BE SURE...IF IT'S
Westinghouse

*Snap-tite
QUICK-CONNECT
QUICK-DISCONNECT COUPLINGS
in larger sizes
immediate delivery
FROM FACTORY STOCKS
SNAP-TITE'S "H" COUPLING, SIZE FOR SIZE, IS THE SMALLEST COUPLING WITH HIGHEST STRENGTH AND HIGHER EFFICIENCY

Snap-Tite's "H" Couplings are now factory-stocked for quick shipment to you, not only in the smaller sizes (below 1" ID) but in all sizes up to and including 3"—in steel, brass, aluminum, and 303 and 316 **Stainless Steel.** And "H" Couplings can be made to your order, up to 10" ID.

Available with valves to give two-way or one-way automatic line shut-off, or without valves for straight-thru flow, "H" Couplings are built to handle high pressures in hydraulic and air systems.

Recessed valve washers . . . fluted valve stems . . . valve stops with minimum flow restrictions . . . large inside diameter—allow maximum flow capacity with lowest pressure drop.

See the Snap-Tite representative in your city or write for Bulletin 240.

***Snap-tite, INC.**

UNION CITY 11, PENNSYLVANIA

SNAP-TITE COUPLINGS CAN HANDLE ALMOST ANYTHING THAT FLOWS

Modernize your v-belt drives with

TAPER-LOCK SHEAVES

—proved in over a million installations!

- **No flange. No collar. *It's different.***
- **Easy on — easy off.**
- **Just tighten the screws that wedge the bushing. Simple, isn't it?**
- **Always a perfect fit on shaft — tight as "shrunk-on."**
- **Complete range of sizes. A, B, C and D grooves, in *stock*.**
- **Try it—and you'll standardize on it!**

Taper-Lock Sheaves, with their precision machining, team up with matched Sealed-Life V-Belts to insure steady performance and unusually long belt life.

DODGE MANUFACTURING CORPORATION, 3300 Union St., Mishawaka, Ind.

CALL THE TRANSMISSIONEER, your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new methods. Look for his name under "Power Transmission Machinery" in your classified phone book, or write us.

DODGE

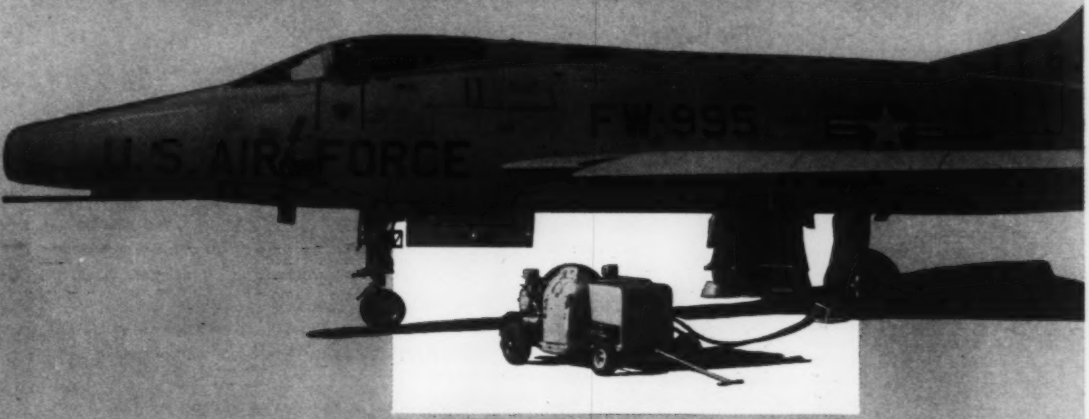
of Mishawaka, Ind.

VICKERS DEMONSTRATES NEW HYDRAULIC STARTER PACKAGE

As a part of its jet engine hydraulic starting system evaluation program, Vickers Incorporated recently demonstrated the ability of its starter package to start Century Series fighters. Acceleration to ground idle speed of the J-57 turbojet engine, installed in a production North American F-100D Super Sabre, was accomplished in times comparable to other known starting means... using only 50 horsepower, prime mover power.

Consisting basically of production Vickers aircraft hydraulic components... performance-proven on almost all existing U.S. military and commercial aircraft... the Vickers starting system offers substantial savings in weight, size, and cost — both initial and maintenance — over other known means. Available as either a ground mobile unit or an aircraft-installed airborne version, the Vickers starter package is capable of dual function. After engine starting, the hydraulic starter motor can serve as an engine-driven pump for aircraft auxiliary power requirements in the airborne version.

For further information regarding Vickers hydraulic starting systems, write for illustrated brochure SE-94a. Also, your nearest Vickers representative can show you the many system combinations available to meet your specific needs.



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ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Circle 433 on Page 19

FACTS about Norgren MICRO-FOG®
Air-Borne LUBRICATION

Norgren MICRO-FOG lubricates all bearings, gears and other components on this turret lathe.

Continuous, Automatic Lubrication for Bearings* ...Oil Always Fresh and Clean

- ***Bearings given Ideal Lubrication*** — Just the right amount of oil is applied to provide the best possible lubrication. Bearings run cooler by as much as 20° F. Bearing wear is minimized, reducing maintenance and replacement costs.
- ***Saving in Lubricant is Big*** — Using only a few ounces of oil per day, MICRO-FOG provides more thorough lubrication than other methods using considerably more.
- ***Costs for Equipment are Less*** — Sumps, pumps, oil filters and high pressure piping are all eliminated by MICRO-FOG, providing a big cut in equipment requirements. Also, fewer oil seals are needed, reducing costly maintenance and down-time.

A MICRO-FOG Lubricator creates an air-borne fog of extremely fine particles of oil that can be appropriately distributed to all lubrication points of even a large machine, automatically lubricating with a continuous, fully protective film of fresh, clean oil.

**Also provides ideal lubrication for gears, chains, cams, slides, ways and other machine components.*

For complete information, call your nearby Norgren Representative, or write for NEW No. 900 CATALOG.

C. A. NORGREN CO.

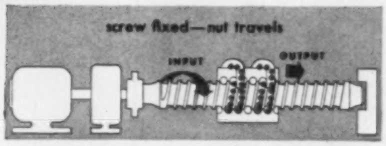
3442 SO. ELATI STREET
ENGLEWOOD, COLORADO

FOR MORE EFFICIENT PRODUCTION—

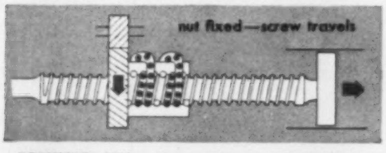
ACTUATE OR POSITION IT BETTER WITH

SAGINAW b/b SCREWS

6 decisive advantages reduce manufacturing problems and costs:



FORWARD: When rotary motion is applied to the screw, the b/b nut is driven along the axis of the screw, changing rotary motion to linear motion.



FORWARD: When rotary motion is applied to the b/b nut, the screw is driven along its longitudinal axis, changing rotary motion to linear motion.

1 **POWER SAVINGS.** Operating with over 90% efficiency, Saginaw b/b Screws permit much smaller motors with far less drain on electrical systems, and also simplify circuitry.

2 **SPACE SAVINGS.** Saginaw b/b Screws themselves are compact. They permit smaller motors and gear boxes and eliminate auxiliary equipment required by hydraulics.

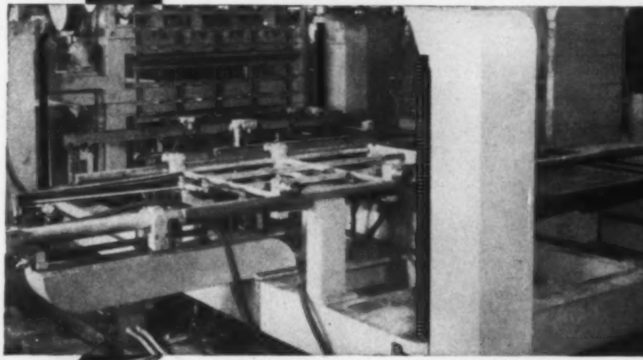
3 **DEPENDABLE PERFORMANCE.** Saginaw b/b Screws are far more reliable than hydraulics or pneumatics. Gothic-arch grooves, yoke deflectors and multiple circuits provide added assurance.

4 **PRECISE POSITIONING.** Saginaw b/b Screws will position components far more precisely than hydraulics or pneumatics; tolerances on position are held within .0006 in./ft. of travel.

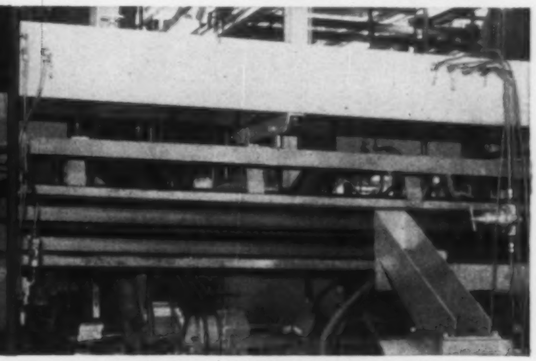
5 **TEMPERATURE TOLERANCE.** Normal operating temperature for Saginaw b/b Screws is from −75°F. to +275°F. But in selected materials, they will function efficiently at temperatures as high as +900°F.

6 **LUBRICATION.** If lubrication fails the Saginaw b/b Screw will still function with remarkable efficiency. Units have been built and qualified for operation without lubrication.

TYPICAL AUTOMATION APPLICATIONS



Automatic indexing device for stacking material. Saginaw b/b Screw used to raise and lower table.



Automatic device for loading and unloading machine. Saginaw b/b Screw used to save power and space.

If you would like further details on the use of Saginaw b/b Screws to increase the efficiency of plant operations, or specific application recommendations for your individual processes, experienced Saginaw engineers are at your service without obligation. Just write or phone us your requirements, or fill in and mail the handy coupon below.

Saginaw

ball bearing Screw

SEND TODAY FOR FREE 36-PAGE ENGINEERING DATA BOOK . . .

or see our section in Sweet's Product Design File

Saginaw Steering Gear Division
General Motors Corporation
b/b Screw and Spline Operation
Dept. 1MD, Saginaw, Michigan

Please send new engineering data book on Saginaw b/b Screws and Splines to:

NAME____________________

COMPANY________________ TITLE________

ADDRESS____________________

CITY______________ ZONE____ STATE____

SAGINAW STEERING GEAR DIVISION OF GENERAL MOTORS • SAGINAW, MICHIGAN

WORLD'S LARGEST PRODUCER OF BALL BEARING SCREWS AND SPLINES

Circle 435 on Page 19

need steel parts?

fully-integrated operations

Claymont's new 100,000 square foot fabrications shop.

... try CLAYMONT

provide you with these advantages

from STEEL PRODUCTION

Claymont is fully integrated—produces all its own steel. Your source of supply is assured.

QUALITY CONTROLS

Claymont controls, tests, inspects throughout every stage of production—within our own plants.

MODERN EQUIPMENT

Claymont's complete range of fabricating equipment performs all these steel plate operations:

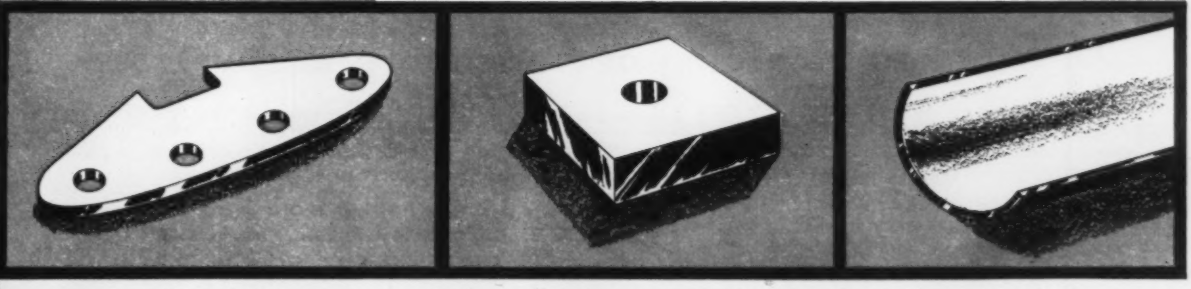
Welding • Shearing • Punching • Milling • Machining • Painting
Bending • Cutting • Boring • Grinding • Chipping • Edge Preparation
Rolling • Pressing • Drilling • Shaping • Priming • Shot Blasting

COMPLETE FACILITIES

100,000 sq. ft. of efficiently organized, production-line Fabrications Shop floor space; streamlined shipping facilities; ready accessibility to water, rail, highway transportation.

...to FABRICATED STEEL PARTS

Claymont provides production weldments or job-shop fabrications in a wide variety of sizes and types of steels; is geared to handle small- or large-quantity jobs with equal facility.



Claymont can meet your steel parts requirements. Contact our nearest office today.

Claymont Steel Products

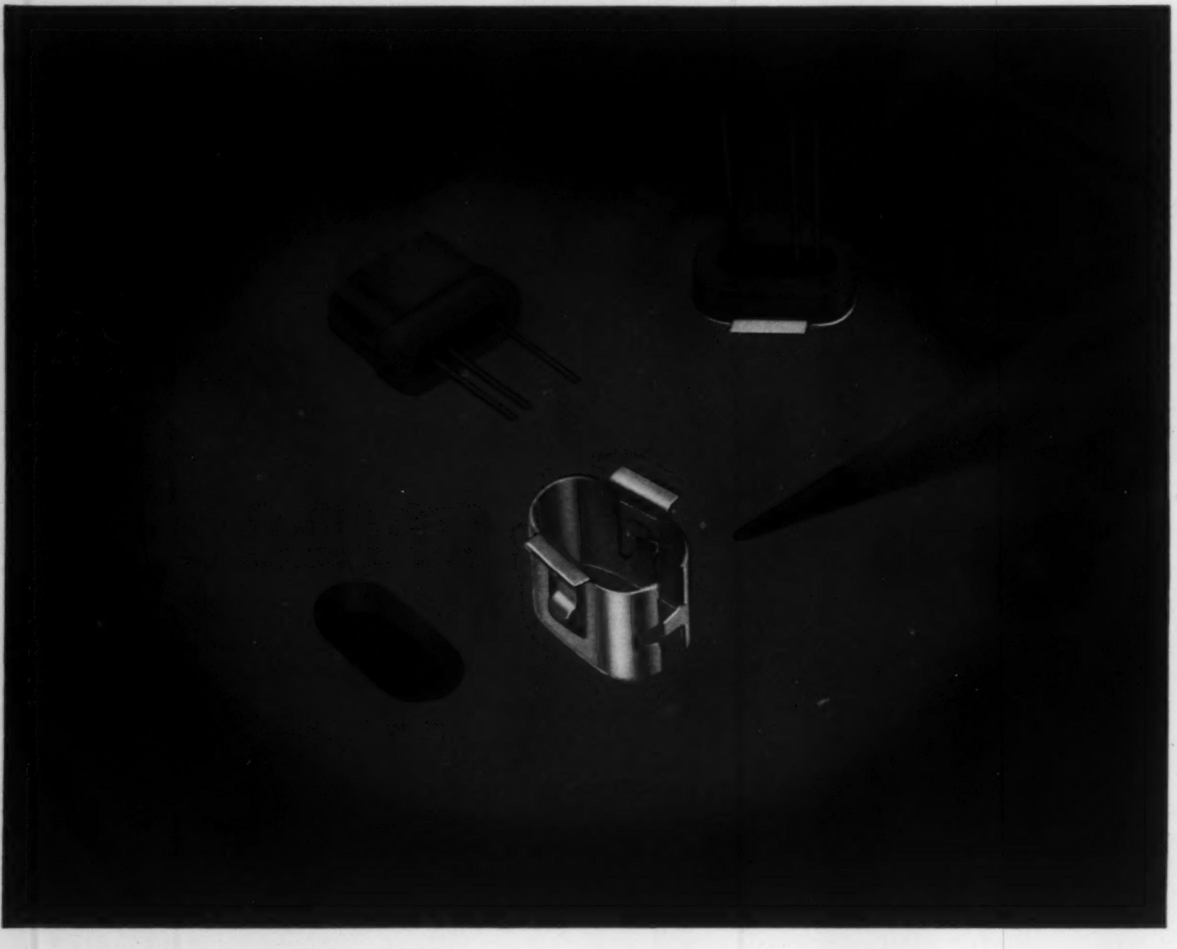
Products of Wickwire Spencer Steel Division • The Colorado Fuel and Iron Corporation

Albuquerque • Amarillo • Atlanta • Billings • Boise • Boston • Buffalo • Butte • Casper • Chicago • Denver • Detroit • El Paso • Ft. Worth • Houston • Lincoln • Los Angeles New Orleans • New York • Oakland • Odessa • Oklahoma City • Philadelphia • Phoenix • Portland (Ore.) • Pueblo • Salt Lake City • San Francisco • San Leandro • Seattle • Spokane Tulsa • Wichita—CF&I OFFICES IN CANADA: Montreal • Toronto—CANADIAN REPRESENTATIVES AT: Calgary • Edmonton • Vancouver • Winnipeg

OTHER CLAYMONT PRODUCTS

Alloy Steel Plates • Large Diameter Welded Steel Pipe • Manhole Fittings and Covers • Flanged and Dished Heads
High Strength Low Alloy Steel Plates • Stainless-Clad Plates • CF&I Lectro-Clad Nickel Plated Steel Plates

5497



Engineered by Tinnerman...

Pea-size **SPEED CLIP®** saves space in missile, makes servicing of transistors easier

Tiny transistors that trigger the controls on a missile or supervise the sequencing on a jet engine are now plugged into pea-size Tinnerman SPEED CLIPS.

A thumb-push locks these front-mounting tubular SPEED CLIPS into punched holes in circuit panels. There's no soldering or riveting, no need for special tools. Spring-steel fingers hold tight; assure a vibration-free assembly. The fully encaged transistor is provided with excellent heat dissipation and can be readily removed for servicing. The SPEED CLIPS can be reused over and over again.

Tinnerman SPEED NUT® Brand Fasteners can save time and money on your production line, too, whether you require a specially engineered fastener or select one of the 9000 variations of existing designs. SPEED NUTS are easy to use, can be applied quickly anywhere along your production line, assuring quality, vibration-proof attachments at low cost.

Discuss your fastening needs with your Tinnerman representative . . . he'll have SPEED NUT ideas to help you make an even better product, at lower cost. You'll find him listed in all major telephone directories. Or write to:

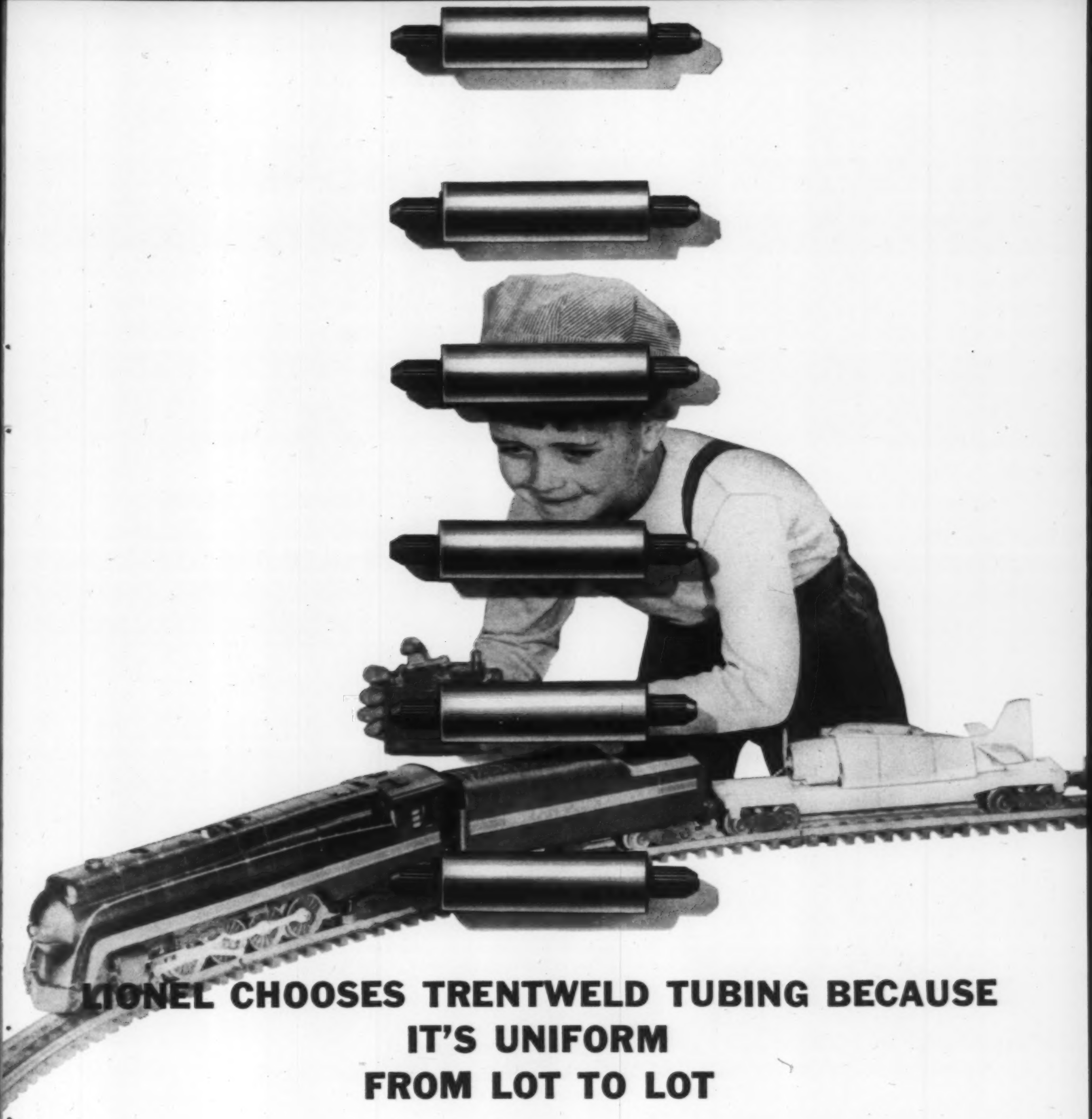
TINNERMAN PRODUCTS, INC.
Dept. 12 • P. O. Box 6688 • Cleveland 1, Ohio

TINNERMAN
Speed Nuts®

FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Mecano-Bundy GmbH, Heidelberg.

Circle 437 on Page 19



LIONEL CHOOSES TRENTWELD TUBING BECAUSE IT'S UNIFORM FROM LOT TO LOT

Going up a 20% grade, or rounding a a bend at the equivalent of a "grown-up" train's 180 mph., this Lionel steam locomotive securely hugs the track. The secret is a small magnet fitted neatly into the axle, which is made of Trentweld® tubing. Why Trentweld? Because its dimensions are always uniform from lot to lot. Costly center grinding is never necessary to make magnet and wheels fit properly.

Trent keeps its tubing uniform by checking all strip going into the welder for both width and tolerance. Furthermore, samples of each lot are tensile tested. Flattening, reverse bend, flare and flange, coil and pressure tests are conducted on all lots intended for corrosive applications. And a unique "single-wall" X-ray inspection is made as your final assurance of a sound, uniform product.

Trent tubing is made by an exclusive welding process — Contour Trentweld — which virtually eliminates the bead. By cold working and annealing after welding, Trent makes the weld itself as strong and corrosion-resistant as the parent metal.

Take advantage of Trent quality when you order tubing. And for further information, write for the Trent tubing handbook, Trent Tube Company, East Troy, Wisconsin.

CONTOUR TRENTWELD

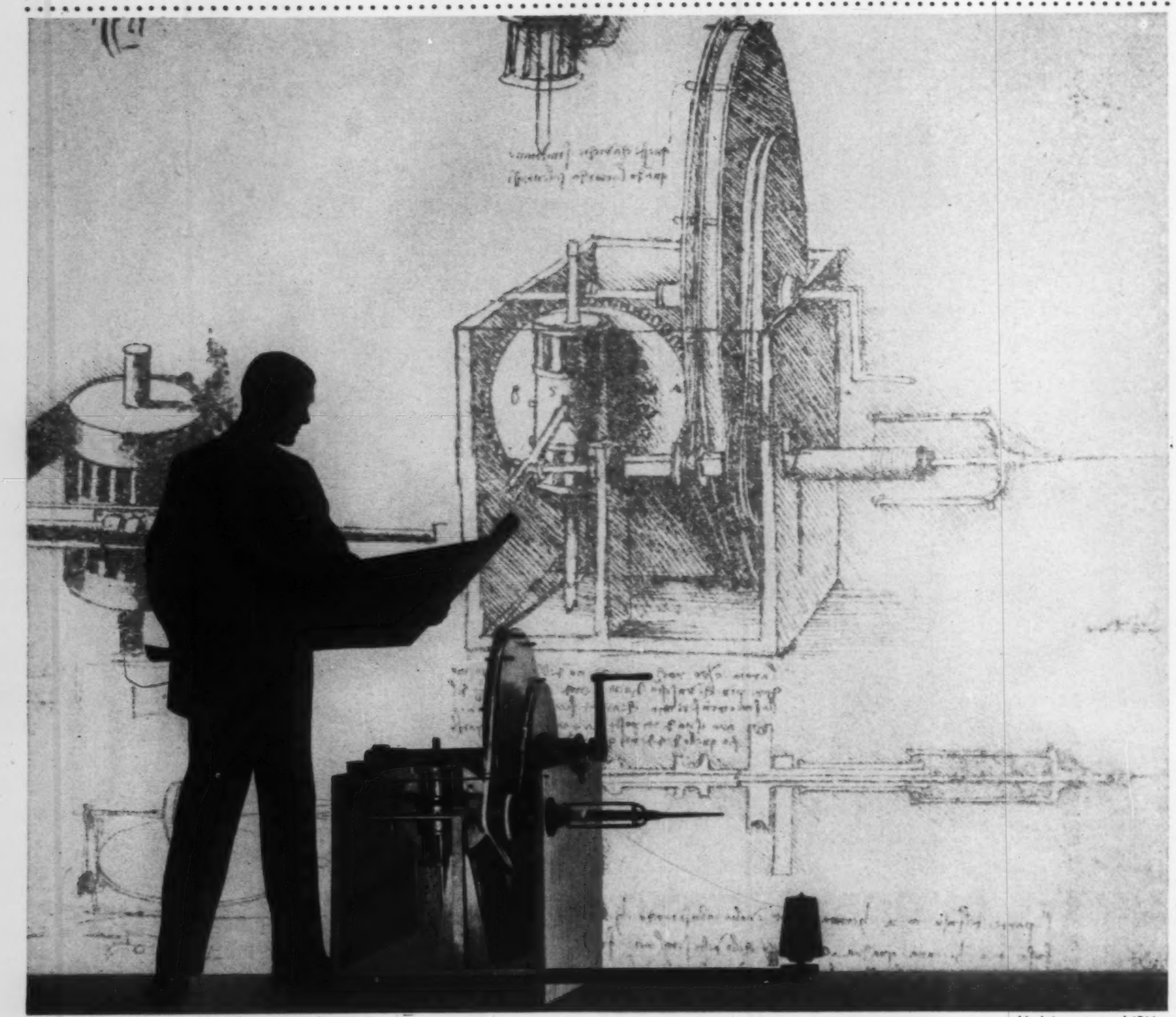
TRENT TUBE COMPANY

A Subsidiary of Crucible Steel Company of America

GENERAL OFFICES: EAST TROY, WISCONSIN
MILLS: EAST TROY, WIS.; FULLERTON, CALIF.

Circle 438 on Page 19

creative designing calls for an open mind



Leonardo Da Vinci's design for a flyer spindle for a loom

Model courtesy of IBM

EVEN DA VINCI'S DESIGN COULD HAVE BEEN BETTER WITH HELP FROM AN SKF ENGINEER—An SKF engineer never has to push one bearing over another, because SKF makes all four types of ball and roller bearings in over 3,000 sizes. This gives every SKF engineer the kind of flexibility he needs to keep an open mind on *any* bearing problem. Give your problem to SKF and see.

7812

Spherical, Cylindrical, Ball, and "Tyson" Tapered Roller Bearings

EVERY TYPE—EVERY USE

SKF®

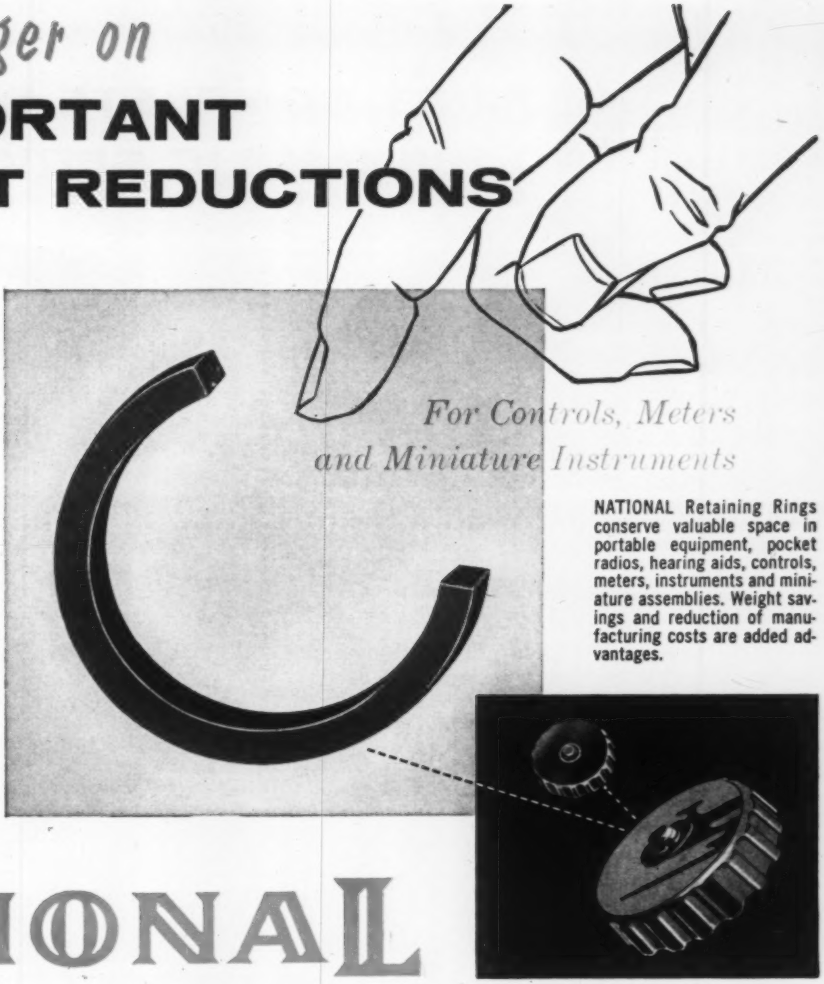
SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

*REG. U.S. PAT. OFF.

Circle 439 on Page 19

Put your finger on

IMPORTANT COST REDUCTIONS



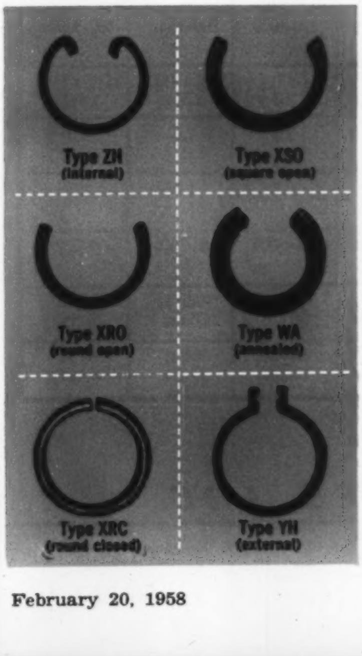
For Controls, Meters and Miniature Instruments

NATIONAL Retaining Rings conserve valuable space in portable equipment, pocket radios, hearing aids, controls, meters, instruments and miniature assemblies. Weight savings and reduction of manufacturing costs are added advantages.

Save time and materials *...and* improve your products *with...*

NATIONAL

RETAINING RINGS



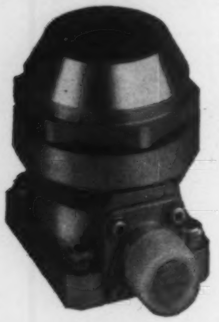
Simplify design by specifying NATIONAL Retaining Rings on shafts and housings. These dependable rings save material, weight and assembly time wherever shoulders or collars are required. Grooving smaller diameters for retaining rings avoids cutting down larger diameter material to form shoulders and collars . . . saves costly machining, speeds assembly. NATIONAL Retaining Rings are service-proven on all types of equipment from heavy machinery to miniature assemblies. Ask for all the cost-saving facts, today!

THE NATIONAL
LOCK WASHER COMPANY
Serving Industry Since 1886
NEWARK 5, NEW JERSEY
MILWAUKEE 2, WISCONSIN

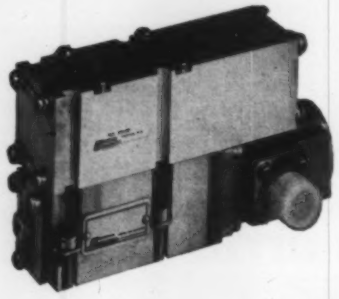
Circle 440 on Page 19

Now...from a single source...

THE FIRST COMPLETE LINE OF ELECTRO-HYDRAULIC SERVO VALVES

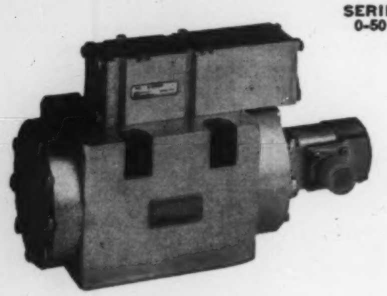


SERIES 100
0-5 gpm

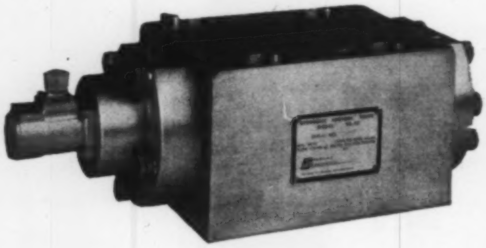


SERIES 200
0-10 gpm

SERIES 300
0-50 gpm



SERIES 500
0-200 gpm



Sanders BOOTSTRAP(T) *Servo Valves for all industrial, marine and aircraft applications*

Sanders Electro-Hydraulic Servo Valves are based on the reliability-proved "BOOTSTRAP" two stage internal force feedback principal. This design converts low input into powerful thrusts, while providing high internal stiffness of control.

These valves have high frequency response, high resolution and low threshold. Large-area internal pilot stage filters plus large orifices and nozzles add up to extra reliability. Manifold mounting allows flexibility in external connections.

Sanders' extensive application experience is at your service in solving servo valve and hydraulic system problems. Extensive manufacturing facilities assure fast, economical production. For complete details about specifications, prices and delivery schedules, write:

TYPICAL SPECIFICATIONS

	SERIES 100	SERIES 200	SERIES 300	SERIES 500
Flow Range (GPM at 1000 psi ΔP)	0-5	0-10	0-50	0-200
Supply Pressure (psi)	200-3000	200-5000	200-3000	500-3000
Overall Size (inches)	2¼ x 2¼ x 2½	5¾ x 1½ x 3	8⅜ x 3¼ x 5⅛	15¼ x 6½ x 4¾
Approximate Weight (pounds)	1.0	3.6	7.5	35.0
Nominal Input Power (watts)	0.1	0.2	1.0	1.0
Coil Resistance (ohms/coil)	100-3000	100-3000	100-3000	100-3000
Amplitude Ratio	–3db at 150 cps	–3db at 80 cps	–3db at 60 cps	–3db at 30 cps
Phase Lag	90° at 150 cps	90° at 80 cps	90° at 60 cps	90° at 30 cps

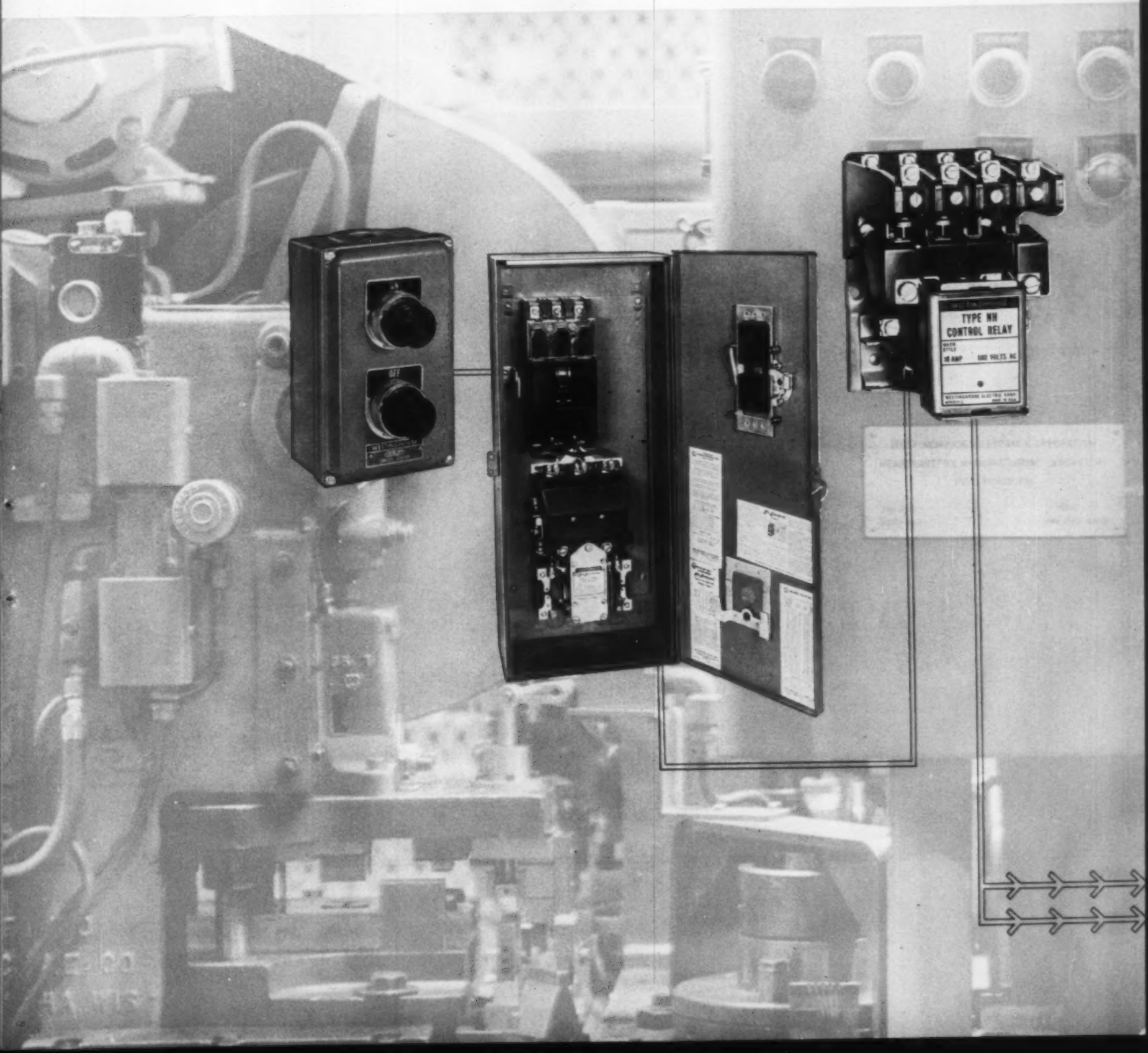
(T) TRADEMARK—SANDERS ASSOCIATES, INC.

SANDERS ASSOCIATES, INC.

NASHUA, NEW HAMPSHIRE • *Inglewood, California* • *Washington, D.C.*

WESTINGHOUSE FOR CONTROL

Westinghouse matched control for machine tools


OFF
TYPE NH
CONTROL RELAY
10 AMP
600 VOLTS AC

PUSH
TEST
WESTINGHOUSE
CONTROL STATION
ON
OFF
WESTINGHOUSE
CONTROL STATION
WESTINGHOUSE
TYPE NH
CONTROL RELAY
MECH
STYLE
10 AMP 600 VOLTS AC
WESTINGHOUSE ELECTRIC CORP.
MADE IN U.S.A.

Westinghouse Push-to-Test and Pushlites

MAKE CONTROL PANEL SPACE WORK TWICE AS HARD

The Westinghouse Pushlite—a pushbutton plus an indicating light—means you need only half the usual number of units per panel. Frees up to one-half of your control panel for other units, other functions.

Matter of fact, you can make this same panel work *many times* harder with the newest addition to the Westinghouse line—a double-pole, double-throw contact unit that gives you twice the use from a single Pushlite! You can't beat that for space economy—just as you can't beat Westinghouse for Pushlite quality.

For added savings, use Westinghouse Push-to-Test indicating lights. They take the guesswork out of indicating light failures—simply press the light to find out whether bulb (or circuit) is out of order. (As you'd expect, both Pushlite and Push-to-Test are Westinghouse developments.)

Westinghouse Life-Linestarters

RUGGED PERFORMERS FOR RUGGED-DUTY APPLICATIONS

Tested on the toughest jobs—in saw mills, cement factories, chemical plants—these Westinghouse Life-Linestarters* have proven to be industry's most dependable performers. There are good reasons for this superiority, of course. Westinghouse Life-Linestarters feature all front-removable parts for fast, easy maintenance.

And additional auxiliary interlocks which can be added to all starters to handle additional loads.

Then there's the exclusive positive-break, bimetallic disc overload relay—gives you the option of hand reset, automatic reset or no-stop operation. (Available with an auxiliary normally open bell alarm contact.)

And the knife-edge fulcrum that prevents armature sticking or binding.

And the exclusive Westinghouse De-ion* arc quench grids that eliminate contact burning and pitting.

And much, much more—

*Trade-Mark

Westinghouse Relays

ASSURE YOU MILLIONS OF OPERATIONS WITHOUT A SINGLE FAILURE

And here's a relay that will match—operation for operation—any relay on the market today. It's good for millions of operations—*to meet the most demanding* machine tool specifications for reliable, long-life relays.

That's why you just don't go wrong when you specify Westinghouse Relays.

By the way—did you know that the bearing parts of the NH Relay are case-hardened to provide tough, wear-resisting surfaces for longer operating life?

That they're available in any combination of normally open or normally closed contacts from two to six poles?

That for applications where space is critical, the new compact Z Relay—double-pole, double-throw—offers extraordinarily long life?

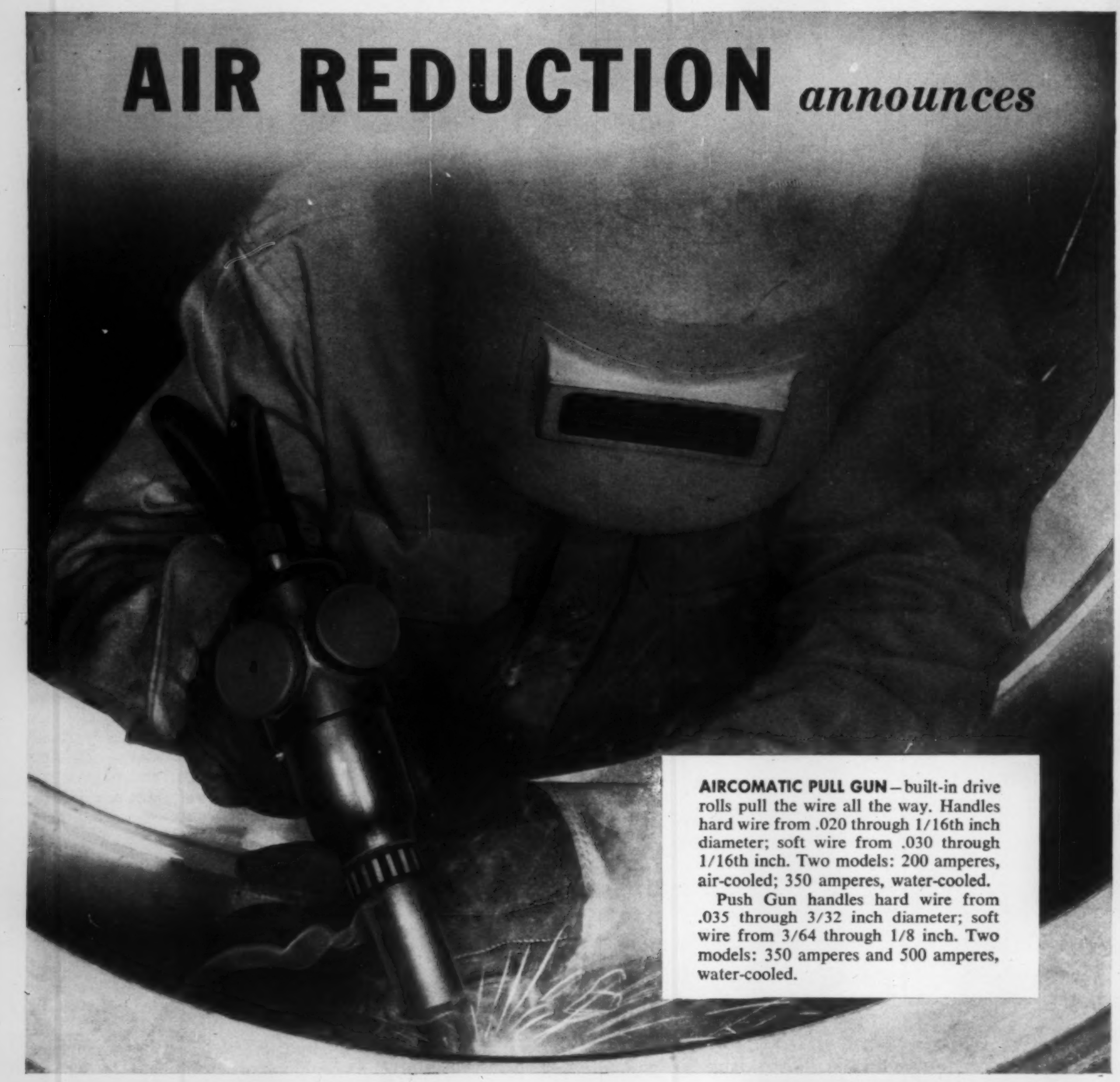
For the whole story on Westinghouse Controls, contact your nearby Westinghouse sales office. Or write for bulletins B-7073, D-B11-000, and B-6749, Standard Control Division, Westinghouse Electric Corporation, Beaver, Pennsylvania.

J-30288

YOU CAN BE SURE...IF IT'S Westinghouse

Circle 442 on Page 19

AIR REDUCTION *announces*

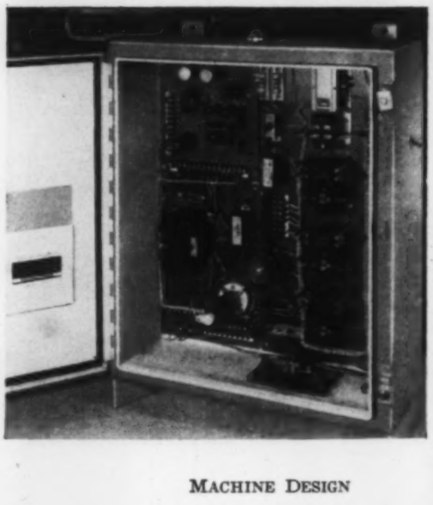


AIRCOMATIC PULL GUN—built-in drive rolls pull the wire all the way. Handles hard wire from .020 through 1/16th inch diameter; soft wire from .030 through 1/16th inch. Two models: 200 amperes, air-cooled; 350 amperes, water-cooled.

Push Gun handles hard wire from .035 through 3/32 inch diameter; soft wire from 3/64 through 1/8 inch. Two models: 350 amperes and 500 amperes, water-cooled.

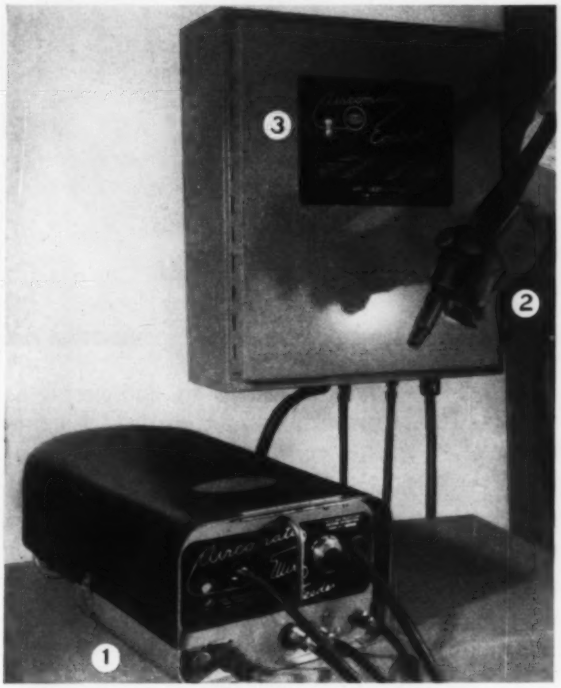
AIRCOMATIC WIRE FEEDER—shown here with cover removed. Motor compartment at left, bracket support for wire at right, reel deck at rear. Note speed control knob and carrying handle on front of unit. Model for use with Push Gun designed with drive rolls substituted for wire bracket. Adaptable for bulk wire system.

UNIVERSAL CONTROL PANEL—for permanent installation near welding power source. Components are easy to reach. Most are plug-in. All sub-assemblies packaged to be replaceable as sub-assemblies. Motor speed control circuits printed on their mounting panel. High efficiency, low maintenance features such as these are typical of the 1958 AIRCOMATIC units.



the new AIRCOMATIC® *package...*
most flexible welding system in the industry

- **push or pull operation—to handle wide range of wire diameters**
- **welds from 1/16" aluminum sheet up**
- **compact, portable—operates up to 100 feet from control panel**
- **stepless self-regulating speed control**



MAIN COMPONENTS of the new Aircomatic package.

1—Portable Aircomatic Wire Feeder, adaptable for push or pull operation; can go anywhere a man can go, up to 100 feet from the control panel.

2—Aircomatic Pull Gun; or, for larger wire, the No. 21 Standard Aircomatic Push Gun (not shown).

3—Universal Control Panel, designed so that every element you ever have to handle is readily available for instant inspection.

The new AIRCOMATIC package, developed by Air Reduction engineers, now enables you to select a system that meets your exact welding needs.

Rugged heart of the system is the electronically controlled AIRCOMATIC WIRE FEEDER, which can be adapted to either pull or push operation.

Teamed with the Wire Feeder is the new AIRCOMATIC PULL GUN, designed particularly for small diameter wires . . . and the No. 21 AIRCOMATIC PUSH GUN, designed for heavier operations.

Completing the package is the all-new AIRCOMATIC UNIVERSAL CONTROL PANEL, featuring many advancements unique to such equipment.

In addition to the basic units, the 1958 Airco line includes remote speed controls, color coded wire guides, and kits for all guns and wire sizes.

Have you a tough application in mind? Send for literature. Then call your nearby Air Reduction sales office—and let a Technical Representative help you choose matched equipment to do the job.

AT THE FRONTIERS OF PROGRESS YOU'LL FIND . . .

AIR REDUCTION SALES COMPANY

A division of Air Reduction Company, Incorporated
150 East 42nd Street, New York 17, N. Y.

Offices in
most principal cities

On the west coast —
Air Reduction Pacific Company

Internationally —
Airco Company International

In Cuba —
Cuban Air Products Corporation

In Canada —
Air Reduction Canada Limited

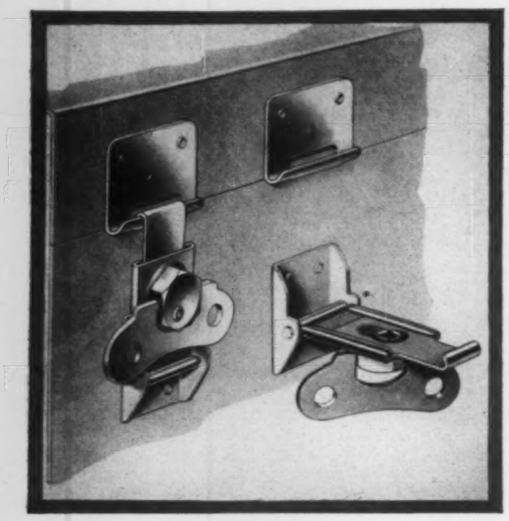
Products of the divisions of Air Reduction Company, Incorporated, include: **AIRCO** — industrial gases, welding and cutting equipment, and acetylenic chemicals • **PURECO** — carbon dioxide — gaseous, liquid, solid ("DRY-ICE") • **OHIO** — medical gases and hospital equipment • **NATIONAL CARBIDE** — pipeline acetylene and calcium carbide • **COLTON** — polyvinyl acetate, alcohols, and other synthetic resins.

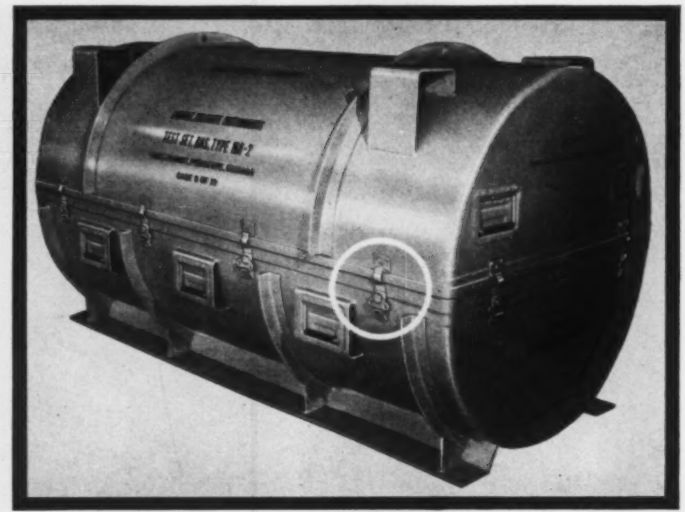
Circle 443 on Page 19

Note—Commercial and Military Packaging Engineers:

Rugged LINK-LOCK

...your best answer to exacting closure problems





Photograph courtesy of Craig Systems, Inc.

LINK-LOCK provides pressure-tight closure on this rigidly specified equipment container

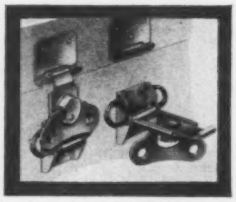
Simmons LINK-LOCK provides quick opening and closing as well as impact-resistant dependability on transit cases manufactured by Craig Systems, Inc., Danvers, Mass.

The cylindrical Craig container above is gasketed and pressure-tight, and contains delicate electronic equipment. Twelve LINK-LOCK fasteners are used on this model.

Here's why LINK-LOCK is ideal for use on military cases produced to exacting specifications as well as on inexpensive commercial containers:

- Impact and shock resistant (positive-locking).
- High closing pressure with light operating torque..... insures pressure-tight seals where required.
- Available in 3 sizes, for heavy, medium, and light duty.
- Compact design...lies flat against case even when unlocked.
- Opening and closing by wing-nut, screwhead, or hex nut.
- Flexible engagement latch design...can be varied to suit different conditions.

Also available: Spring-Loaded LINK-LOCK. Ideal for the less expensive containers where costs won't permit precision production. Spring provides take-up to compensate for set in gasketing, irregularities of sealing surfaces, and mounting inaccuracies.



Where does the versatile Simmons LINK-LOCK belong in your design? For complete information and specifications, send for the Simmons Catalog today. Samples and engineering service available upon request.

SIMMONS
FASTENER CORPORATION
1756 North Broadway, Albany 1, New York

QUICK-LOCK • SPRING-LOCK • ROTO-LOCK • LINK-LOCK • DUAL-LOCK

See our 8 page catalog in Sweet's 1958 Product Design File

Circle 444 on Page 19

NEW

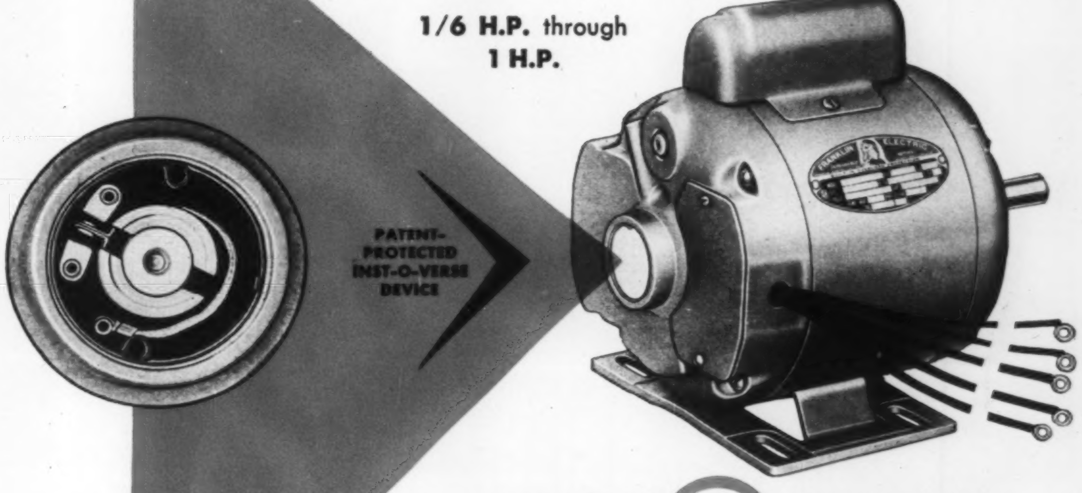
Franklineered®

INSTANT-REVERSING MOTORS

FOR YOUR PRODUCT

. . . Franklin Motors with INST-O-VERSE® apply full power for instant reversing in response to manual or automatic signal.

1/6 H.P. through **1 H.P.**



INST-O-VERSE

patent-protected device employs radically new principle. Motor reversal is instant due to independence from relays or delaying mechanical contact with centrifugal switch. Silver contacts on shaft-riding, low-friction nylon "shoes" are automatically preset for reversal with each rotation change. Superior longevity over conventional mechanisms results because INST-O-VERSE does not interrupt a circuit and is not subject to contact arcing. The device is completely protected from dirt or damage in the covered end bell of the motor.

EXAMINE
INST-O-VERSE
MOTORS IN
BOOTHS 484-486
AT THE DESIGN SHOW

INSTANTLY UTILIZES FULL TORQUE CAPACITY OF MOTOR FOR REVERSING ROTATION

- AVAILABLE IN 1 PH., 1725 R.P.M., 115 OR 230 V., 1/6 THROUGH 1 H.P., SLEEVE OR BALL BEARING MOTORS.
- NEMA FRAME, OR APPLICATION-ENGINEERED MOUNTINGS.
- REVERSING ACTION OF 1-PHASE FRANKLIN INST-O-VERSE MOTORS IS EQUAL TO CONVENTIONAL THREE-PHASE REVERSING MOTORS.
- INST-O-VERSE ENABLES USE OF 1-PHASE INSTEAD OF 3-PHASE MOTORS FOR CUTTING COSTS.

Franklin Electric Co., Inc.

345 EAST SPRING STREET • BLUFFTON, INDIANA

Write for your copy of "INST-O-VERSE MOTORS."

Circle 445 on Page 19

the profit you left behind

There it lays in the dirt. Your machines and equipment ground off in the grit, pounded off in the rock and ore. You can almost see the wear that shut down your machines too soon . . . idled your men too long . . . bled your profits too much.

Is there *one* material, *one* metal that can stop this excess wear waste?

One? It takes many alloys, engineered alloys (some you may never have heard of). It takes a list of Amsco® Alloys to span the entire range of wear applications.

Amsco Alloys that can work a full shift where severe abrasion knocked out toughest metals in three hours. Amsco Alloys that can belt rock and ore all day, and work tomorrow, too. Amsco Alloys that can work any abrasion-impact combinations you face and still resist the wear, stop the waste . . . save the profit!

When you need the *best* alloy for the job, you'll find it *first* among the Amsco Alloys . . . engineered by America's largest producer of cast manganese steel and specialists in wear-resistant metals.

AMERICAN
Brake Shoe
COMPANY

AMSCO

American Manganese Steel Division · Chicago Heights, Illinois

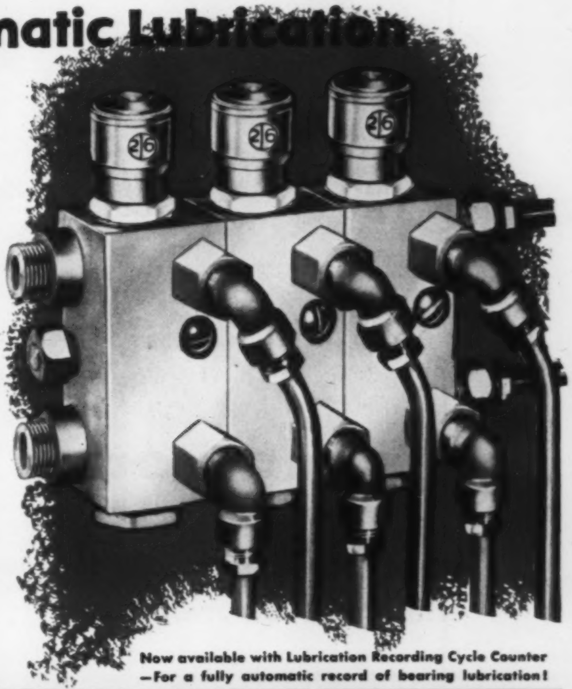
Design for toughest lubrication requirements!

ALEMITE

REG. U. S. PAT. OFF.

Accumatic®

Centralized Automatic Lubrication



Alemite Type II Accumatic Valves meet big-volume requirements . . . handle difficult multiple-bearing lubrication under all conditions. Fully sealed for *clean* lubrication of power shovels, cement kilns, conveyors—any outdoor or indoor installation. Operate whether completely immersed in fluid . . . covered by dirt or grit . . . or protected by anti-corrosive paint. For fluid oil or light grease. Four sizes, delivering from .050 to .500 cu. in. of lubricant. Fully hydraulic—no springs to adjust or replace.

Factory-Tested—Field-Proved!

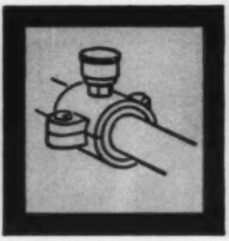
Tests show no appreciable variation in the amount of lubricant discharged after 73,312 cycles—equal to *122 years of twice-a-day service!*

Alemite Accumatic Type II Offers All These Advantages:

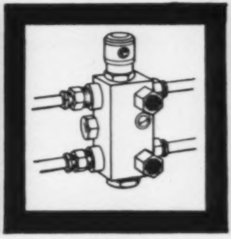
- Prevents application of wrong lubricant.
- Seals completely against dirt, grit, water.
- No parts are neglected—lubricates bearings that are inaccessible by hand or dangerously located.
- Eliminates product spoilage due to over-lubrication.
- Eliminates point-by-point lubrication methods—services all bearings in one operation.
- Delivers exact amount of lubricant to bearing.

Now available with Lubrication Recording Cycle Counter—For a fully automatic record of bearing lubrication!

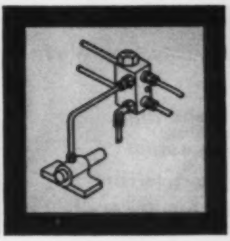
Can be designed into any machine, in 4 EASY STEPS!



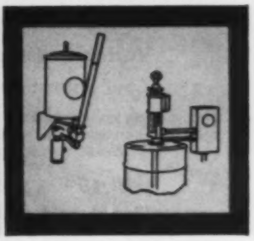
1. Remove grease cups or grease fittings.



2. Connect each valve in system to its two lubricant supply lines.



3. Connect valve outlets to inlet of bearings. (Each valve serves two bearings.)



4. Provide central pump for supplying lubricant to system.

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STEWART-WARNER
CORPORATION

Symbol of
SW
Excellence

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Accumatic

Please send me my free copy of the Alemite Accumatic Catalog.

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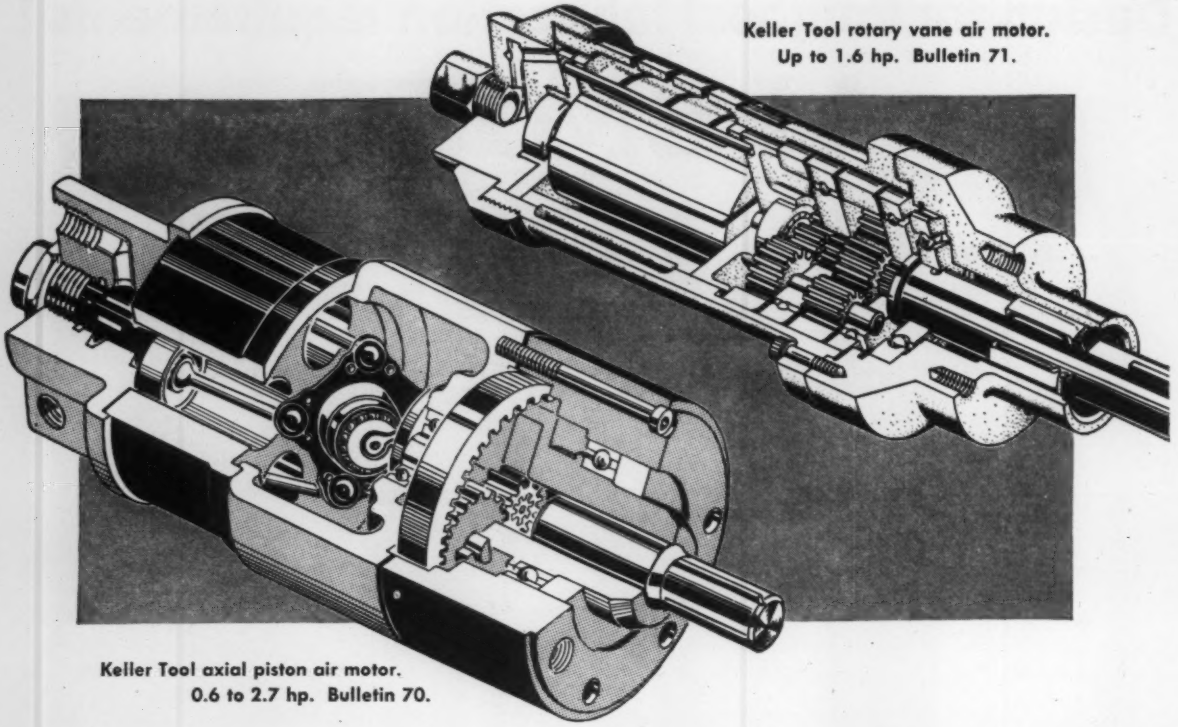
Circle 447 on Page 19

Keller Tool rotary vane air motor.
Up to 1.6 hp. Bulletin 71.



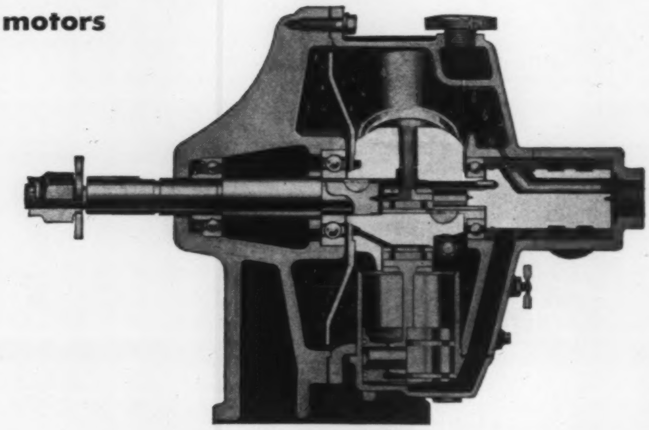
Keller Tool axial piston air motor.
0.6 to 2.7 hp. Bulletin 70.

Air power is idea power . . .

when your design calls for motors with these features:

High starting torque
Reversibility without power loss
Variable speed, easily controlled
Cool operation
Instantaneous starts and stops
Consistent torque output
Non-sparking characteristics
Thrust and axial spindle loads
Enclosed construction
Output from ½ to 16 hp.

AIR MOTORS are your answer
Write for detailed bulletins.



Gardner-Denver five-cylinder radial
air motor. 3 to 16 hp. Bulletin AM-1.

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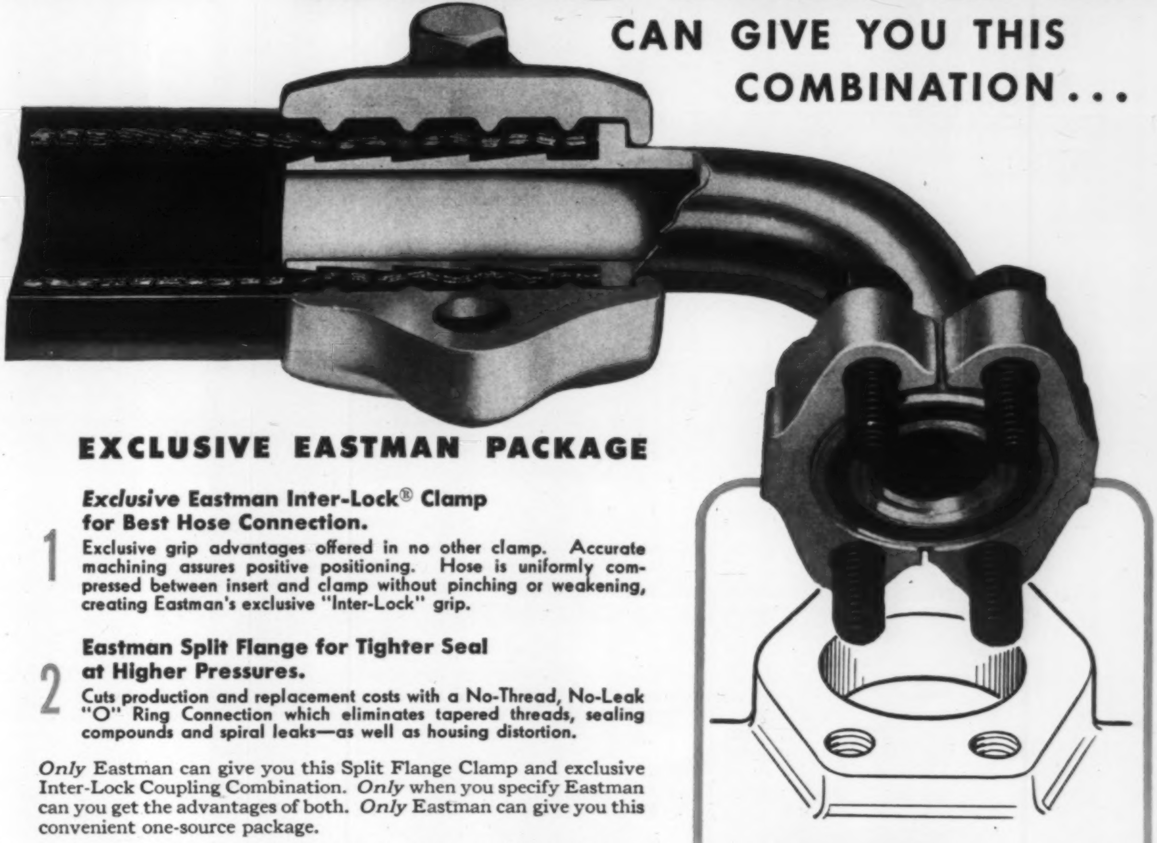
GARDNER - DENVER

Gardner-Denver Company, Quincy, Illinois
In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

Circle 448 on Page 19

ONLY Eastman

CAN GIVE YOU THIS COMBINATION . . .



EXCLUSIVE EASTMAN PACKAGE

1 ***Exclusive* Eastman Inter-Lock® Clamp for Best Hose Connection.**

Exclusive grip advantages offered in no other clamp. Accurate machining assures positive positioning. Hose is uniformly compressed between insert and clamp without pinching or weakening, creating Eastman's exclusive "Inter-Lock" grip.

2 **Eastman Split Flange for Tighter Seal at Higher Pressures.**

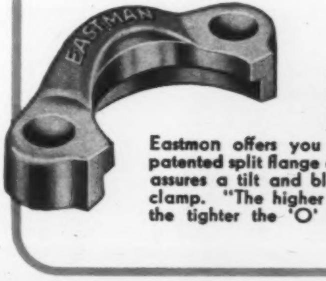
Cuts production and replacement costs with a No-Thread, No-Leak "O" Ring Connection which eliminates tapered threads, sealing compounds and spiral leaks—as well as housing distortion.

Only Eastman can give you this Split Flange Clamp and exclusive Inter-Lock Coupling Combination. *Only* when you specify Eastman can you get the advantages of both. *Only* Eastman can give you this convenient one-source package.

This combination is ideal for *Original* heavy duty equipment. It is the only answer to high pressure requirements because it meets highest OEM specifications and easy field replacement needs.

Available with stem inserts in angles from 0° thru 90°; sizes from ¼" thru 2"; recommended pressures from 375 p.s.i. to 5000 p.s.i.

Look to Eastman . . . America's No. 1 OEM specification . . . for all your fluid power line requirements . . . for the best assembly, the best performance, the best service. Eastman is also recognized for its leadership in engineering design and development . . . backed by unequalled years of experience in the field. ***It pays to submit your original specifications for your first quotation to Eastman!***

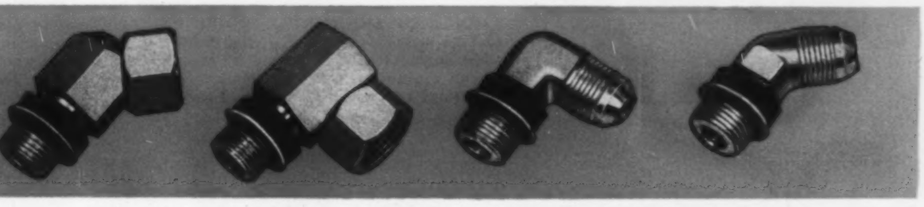


EASTMAN SPLIT FLANGE

Eastman offers you the famous patented split flange design which assures a tilt and blowout proof clamp. "The higher the pressure the tighter the 'O' Ring seal."

Eastman "O" Ring Boss Fittings

Now available with new "Back-up" washer and locknut eliminating "O" Ring extrusion per SAE specifications.



Eastman *first in-the-field*

Manufacturing Company
Dept. MD-2
Manitowoc, Wis.

DESIGN AND DEVELOPMENT ENGINEERS:

Write for Technical Bulletin 200 for Information and Specifications on Complete Eastman Line of Hydraulic Hose Assemblies, and Bulletin 40 on Inter-Lock clamp.

available in . . .

SPLIT PHASE,
PERMANENT SPLIT CAPACITOR,
CAPACITOR START-INDUCTION RUN,
POLYPHASE

NEW!

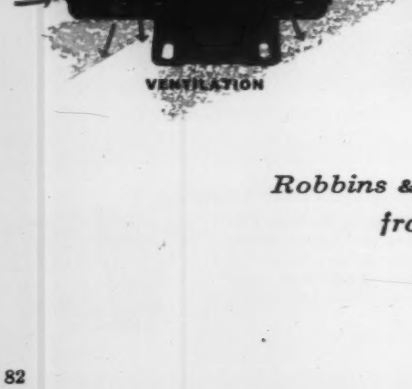
CLEAN, MODERN DESIGN—Lightweight, die-cast aluminum head ends accurately fit precision machined steel body, assuring rigidity and good alignment. External finish is smooth, flaw-free . . . blends well with any color.

IMPROVED, DOUBLE-END VENTILATION—Ventilating fans are integral with die-cast aluminum squirrel cage rotor, providing effective cooling of the windings from both ends for long life. Properly located openings give maximum cooling with minimum internal parts exposure.

MYLAR* POSITIVE INSULATION—Mylar* polyester film laminated to rag paper insulates slot cells and other strategic areas. Excellent dielectric qualities and resistance to tearing and aging, affording virtually permanent protection against dust, moisture and heat damage.

CHOICE OF MOUNTINGS, BEARINGS—Rigid, welded base or vibrationless, ultra-quiet resilient mounting with motor hubs floating on rubber cushioning rings permanently bonded to inner and outer metal bands. Either sleeve type or fully sealed ball bearings available. If desired, special construction permits re-lubrication of ball bearings. Bearings seat in precision bored steel rings cast into the aluminum heads.

**DuPont registered trademark*



VENTILATION

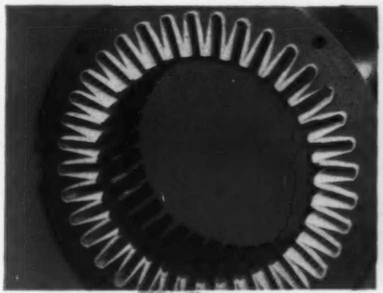
Robbins & Myers build motors
from 1/200 to 200 horsepower

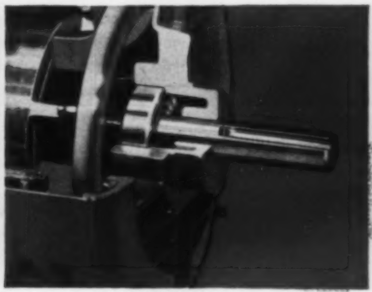
R&M

R & M's BROAD LINE OF SMALLER, LIGHTER, FRACTIONAL HP MOTORS

Robbins & Myers Re-Rated Frames 56 and 48

Here's a dynamic new motor—smaller, lighter, more versatile than older frame motors—yet with undiminished performance and reserve power. Completely new R&M "Model R" fractional horsepower motors will perform dependably and enhance the appearance and acceptability of your products. They range from 1 to ⅛ HP in types for all your applications: polyphase, permanent split capacitor, capacitor start single phase and (in the smaller ranges) split phase types. Designed in new NEMA frames 56 and 48, they are *lighter* due to new applications of aluminum, steel and copper . . . *smaller* thanks largely to a unique new ventilating system . . . *more versatile* because of weight, size and many other design features involving frames, mountings, insulation etc. Look over the big advantages these motors offer you! Then write today for R&M Bulletin No. 450–MD.


MYLAR SLOT CELL INSULATION


BEARINGS

TOTALLY ENCLOSED—FAN COOLED

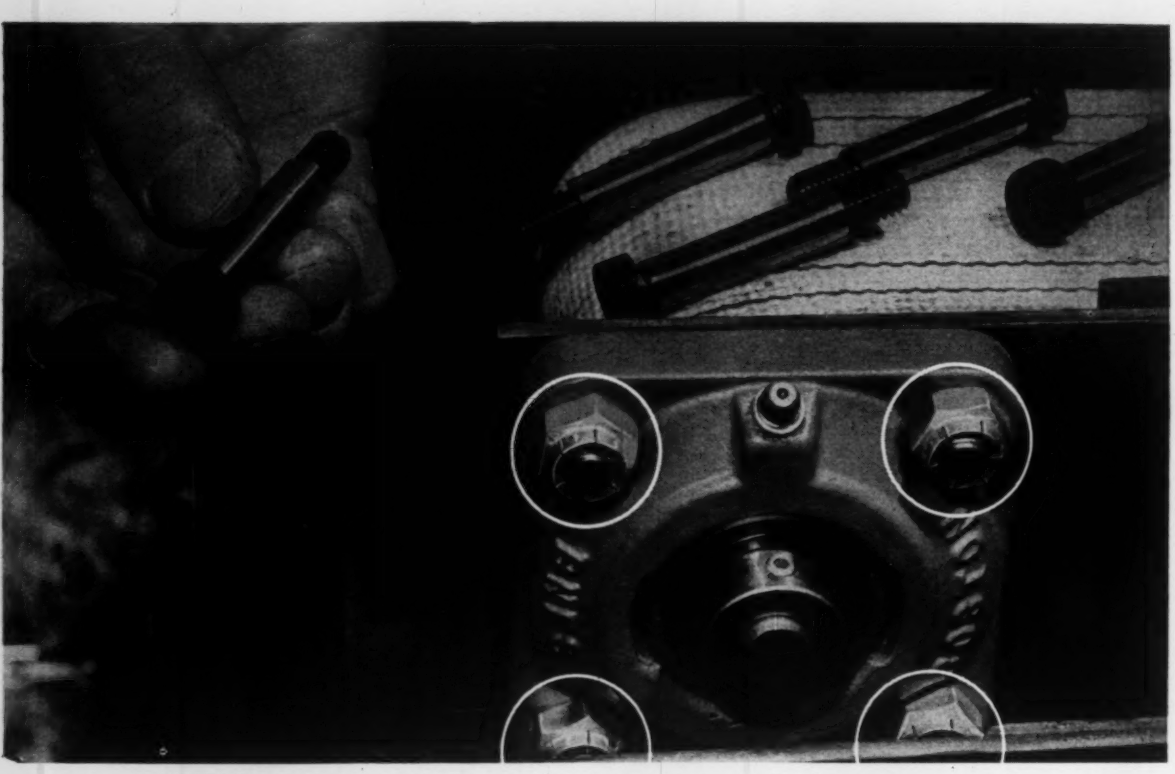
ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO / BRANTFORD, ONTARIO

MOTORS FANS HOISTS MOYNO® PUMPS PROPELLAIR® FANS

LIVE BETTER ELECTRICALLY

Circle 450 on Page 19



FLEXLOC self-locking nuts on this conveyor assembly stay tight despite vibration, yet can be removed quickly and easily for maintenance purposes and can be reused without loss of locking power.

FLEXLOC self-locking nuts help you build vibration-proof assemblies economically

1-piece design eliminates auxiliary locking devices, reduces your cost f.o.b. bolt

FLEXLOC self-locking nuts not only assure you vibration-proof fastening; they also help simplify your inventory and reduce assembly time. A FLEXLOC is a 1-piece, self-locking unit requiring no cotter pins, lockwashers or jam nuts. There are no auxiliary locking elements to put together, come apart or get lost; no inserts to pop out or deteriorate.

FLEXLOCS can be used as locknuts or stopnuts. They lock, seated or not, wherever wrenching stops and will not work loose despite severe vibration. Uniform locking torques permit more accurate preloading of bolts, studs and screws and minimize wear on power wrenching tools. FLEXLOCS are easy to remove and can be used repeatedly. They are unaffected by dryness, moisture or oil and are serviceable throughout a wide temperature range.

Off the shelf, a FLEXLOC may cost slightly more than an ordinary nut; but f.o.b. your product, it usually costs you less . . . assembly time, labor costs and reliability all considered. See your authorized SPS distributor for more information. He carries a complete line of FLEXLOC self-locking nuts—regular and thin height—in a full range of standard materials and sizes (including microsizes). Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

VIBRATION TESTS—LOCKWASHERS/PLAIN NUTS VS. FLEXLOC SELF-LOCKING NUTS

Specimen No.	Washer Type	Bolt and Nut Size	Seating Torque in.-lb.	Vibration Time to Failure
1	Serrated	¼—20	20	30 sec.
2	Serrated	¼—20	40	30 sec.
3	Split	¼—20	20	60 sec.
4	Split	¼—20	40	13 sec.
5	Flexloc Nut	¼—20	20	1 hr.—no failure
6	Flexloc Nut	¼—20	40	1 hr.—no failure
7	Plain Nut	¼—20	20	30 sec.
8	Plain Nut	¼—20	40	45 sec.

Table shows results obtained when lockwasher/plain nut combinations and FLEXLOC self-locking nuts were vibrated at various tightening torques. Tests were run according to AN specifications.

We also manufacture precision titanium fasteners. Write for free booklet.

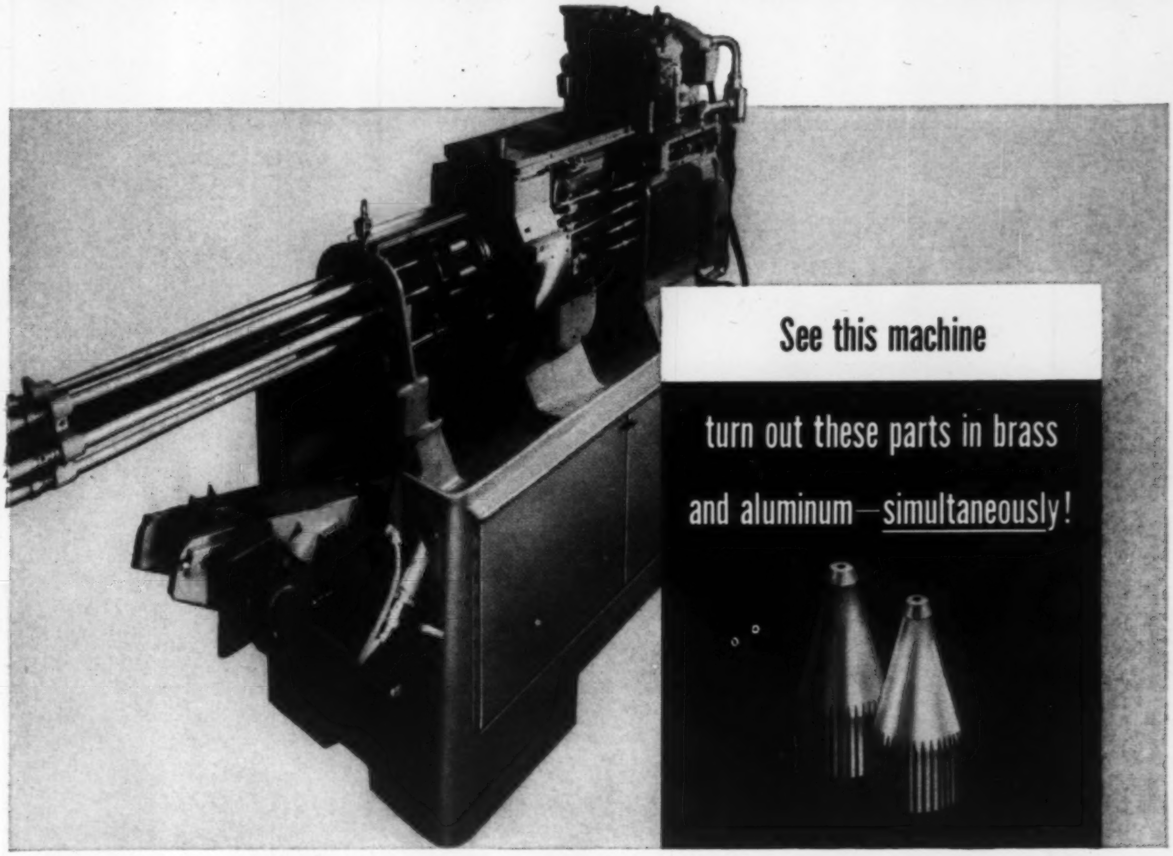
SPS Jenkintown • Pennsylvania

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co., Inc. • Nutt-Shel Corporation • SPS Western • Standco Canada Ltd. • Unbrako Socket Screw Co., Ltd.

Circle 451 on Page 19

BETTER MACHINING STARTS WITH ALCOA SCREW MACHINE STOCK

Alcoa proved it in Cleveland . . . now will prove it in other cities



See screw machine parts produced in aluminum at less cost than steel or brass

When Alcoa and National Acme Company sponsored a machining demonstration in Cleveland last September, 700 design and production engineers and purchasing people saw aluminum and brass parts produced *simultaneously* on a six-spindle automatic screw machine—saw documented evidence that screw machine parts can be produced cheaper in aluminum than in brass or steel. Many expressed frank amazement at the cost comparisons shown.

Here is eye-opening machining news for all industry. Now *you* can see this demonstration, which Alcoa will sponsor in Chicago, Boston,* New York, Detroit, Los Angeles and other important centers.

If your function is design or production of products that use screw machine parts, you will find the Alcoa machining demonstration an enlightening experience. You will see how aluminum offers the ultimate in design freedom because it's so workable, so easy to machine—because it gives better finishes including anodized color. You will see the new color movie about Alcoa Screw Machine Stock, "The Four Amazing Alloys."

Send in the coupon for your invitation—and for a Design Calculator (slip-stick) for use with Alcoa® Aluminum Screw Machine Stock.

WE CHOSE
ALCOA ALUMINUM
SCREW MACHINE STOCK
ALUMINUM COMPANY OF AMERICA

"ALCOA THEATRE"
Exciting Adventure
Alternate Monday Evenings

*March 5, 6—Somerset Hotel, Country Room
400 Commonwealth Ave., Boston, Mass.

Aluminum Company of America
873-B Alcoa Building, Pittsburgh 19, Pennsylvania

Yes, I want to attend the Alcoa machining demonstration nearest my area________________.

Please send my invitation—and Design Calculator.

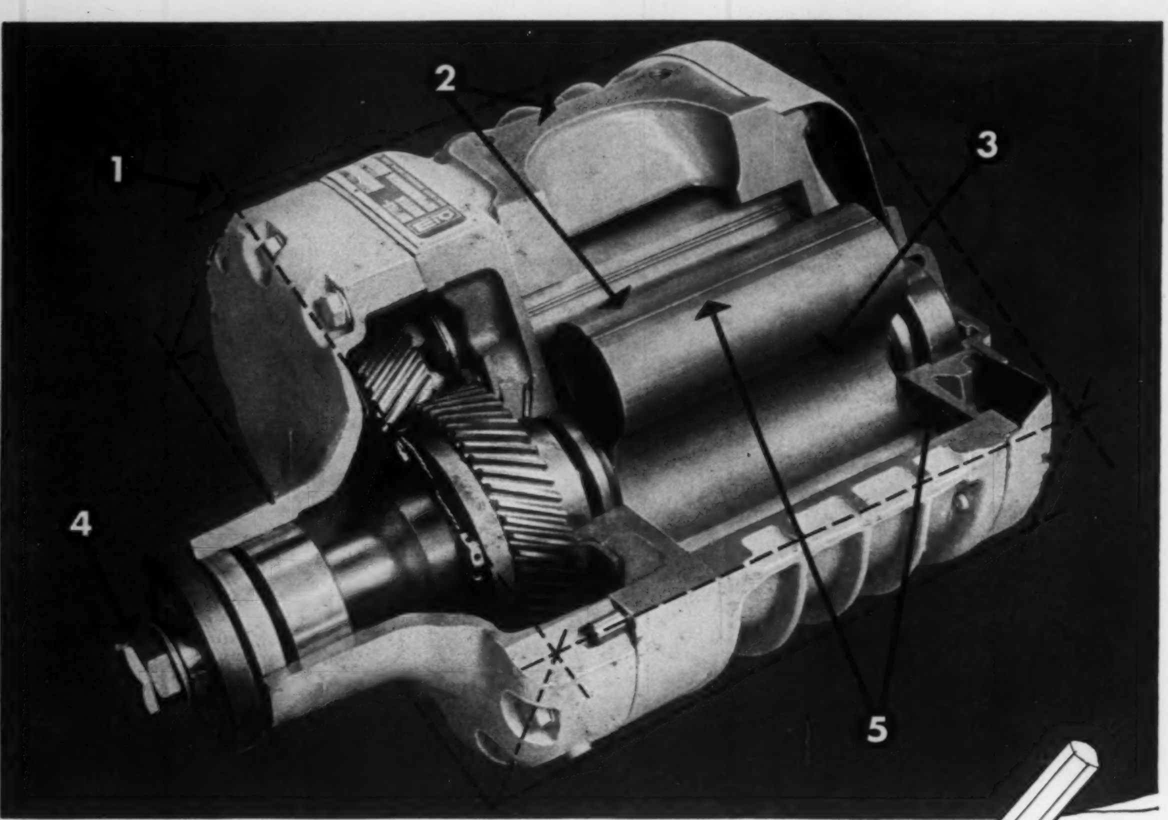
Name____________________

Position____________________

Company____________________

Address____________________

City__________ Zone_____ State________



The **BIG** difference in blowers is...

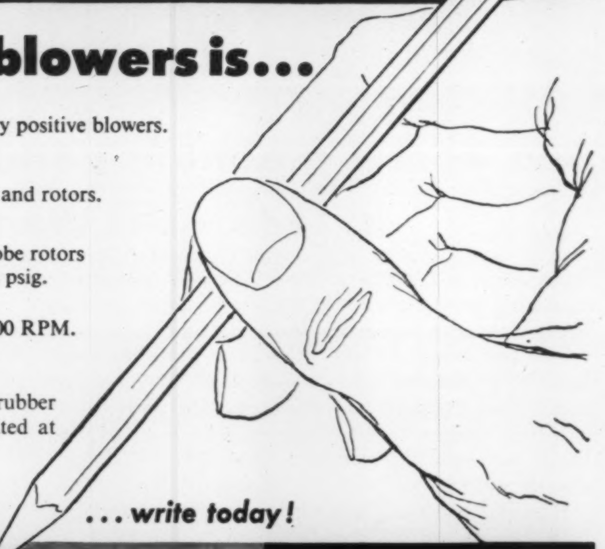
HERE ❶ Smallest cube dimensions of all rotary positive blowers.

HERE ❷ Lightest weight with aluminum housing and rotors.

HERE ❸ Wide pressure range—exclusive 3-lobe rotors deliver pressures from 1 through 12 psig.

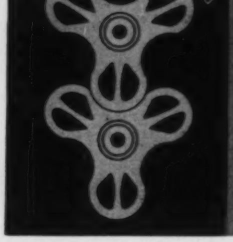
HERE ❹ Direct drive at 1160, 1750 and 3500 RPM. Belt drive at intermediate speeds.

AND HERE ❺ Exclusive formica wear strips and rubber grid seals prevent freezing if operated at excessive pressures.



The performance figures are convincing . . . . . . write today!

Miehle Dexter



3-LOBE
ROTARY POSITIVE
BLOWERS

Important advantages
in pressure range,
size, weight,
cost, service!

Miehle-Dexter Supercharger Division of The Christensen Machine Company, 100 Fourth St., Racine, Wis.

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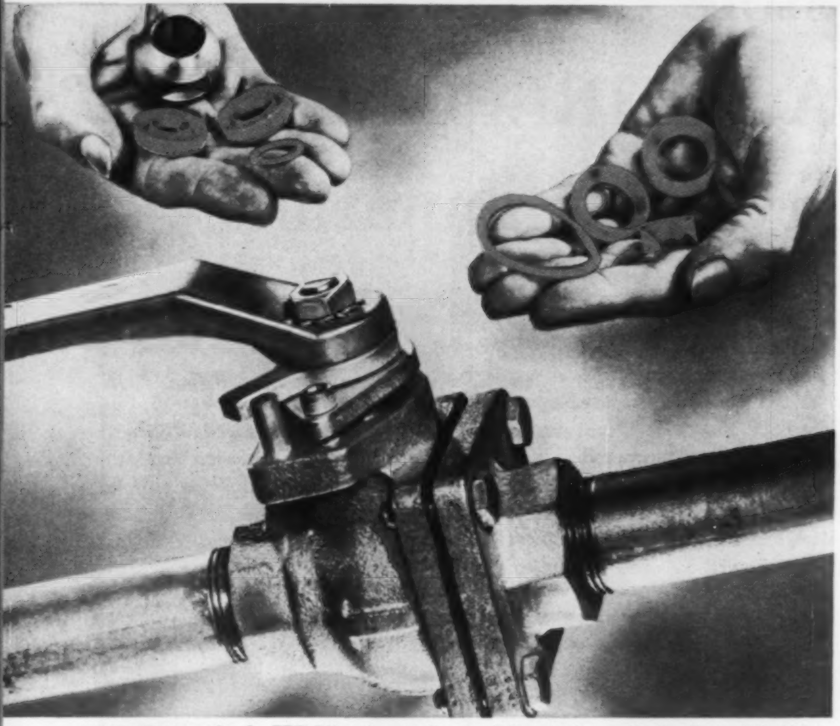
Better Things for Better Living
. . . through Chemistry

PRODUCT ENGINEERING NEWS

LATEST PROPERTY AND APPLICATION DATA ON

TEFLON® tetrafluoroethylene resins



VALVE SEALS made of a TEFLON resin permit easy opening or closing of ball valve under any pressure. Due to use of a TEFLON resin, no oil or grease is needed for lubrication, and maintenance is practically eliminated. (Valve by Rockwood Sprinkler Company, Worcester, Massachusetts.)

Seals of TEFLON® tetrafluoroethylene resins eliminate lubrication ... cut maintenance

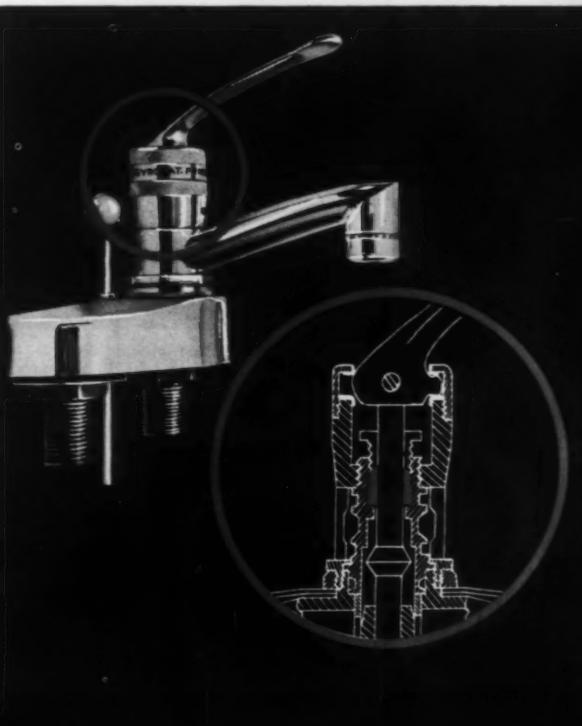
Designing a ball valve which needs no lubrication was made possible by utilizing seals molded from a TEFLON tetrafluoroethylene resin. Designing with TEFLON resins also allows minimum maintenance of the valve, since the seals are tough and durable and resistant to any chemical or corrosive that can be handled by the valve's stainless steel body. The extremely low coefficient of friction of TEFLON resins makes the valve quick-operating with no tendency to stick. Its design, with the ball forced against a seal of the resin by spring pressure, assures a drip-tight closure even at low pressures.

TEFLON resins are rated for use at temperatures to 500°F. Chemically, they are among the most inert materials known to science. Parts made of TEFLON resins are tough and durable. So outstanding are these resins as sealing and gasketing materials, that their use is often specified even where their exceptional heat- and chemical-resistance are not required. In particular, TEFLON resins are used for *extra safety* and *reliability*.

……

Packing gland of TEFLON® tetrafluoroethylene resins improves assembly and performance of new mixing faucet

A packing made of a TEFLON resin permits smooth rotation and easy up-and-down motion, yet prevents any seepage of water through the stem of this faucet. It can be assembled into the valve very easily, quickly and efficiently, and the adjustment on the packing can be uniformly pre-set by machine. This increases production, saves money in assembly and virtually eliminates packing replacements in the field. (Faucet by Gyro Brass Mfg. Corp., Westbury, L. I., N.Y.; parts molded of TEFLON tetrafluoroethylene resins by Sparta Mfg. Co., Dover, Ohio.)



WRITE FOR DETAILS on how to use Du Pont TEFLON tetrafluoroethylene resins in your own designs; E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept., Room 222, Du Pont Bldg., Wilmington, Del.
In Canada: Du Pont Company of Canada (1956) Limited, P.O. Box 660, Montreal, Quebec.

TEFLON® *is a registered trademark*

TEFLON is Du Pont's registered trademark for its fluorocarbon resins, including the tetrafluoroethylene resins discussed herein. This registered trademark should not be used as an adjective to describe any product, nor should it be used in whole, or in part, as a trademark for a product of another concern.

Watch the "Du Pont Show of the month"—90 minutes of the very best in live television—CBS network

Circle 454 on Page 19

Dayton Variable Speed Cog-Belts* make possible Unique Drive for RCA WHIRLPOOL Washer-Dryer Combination

Whirlpool Corporation turned to Dayton with a revolutionary new drive design for their RCA WHIRLPOOL Washer-Dryer Combination. What they proposed was a variable speed V-Belt transmission to replace the conventional gear case. Potential benefits to users of the Washer-Dryer Combination was a smoother, more readily adjusted, quieter running drive, and lower operating costs.

Dayton V-Belt Engineers analyzed the design, then recommended Dayton Variable Speed Cog-Belts* and furnished samples for initial testing. These first tests proved that the design would work and that the specially designed Dayton Cog-Belts were non-dusting, flexible enough to work over small diameter sheaves, and would pick up the load smoothly and without slipping.

From then on, engineers for both Dayton and Whirlpool worked as a team through the design, redesign and production design stages with Dayton furnishing new samples at each stage. Not only was the design perfected through this coordinated activity but it was mechanically simplified and its cost reduced.

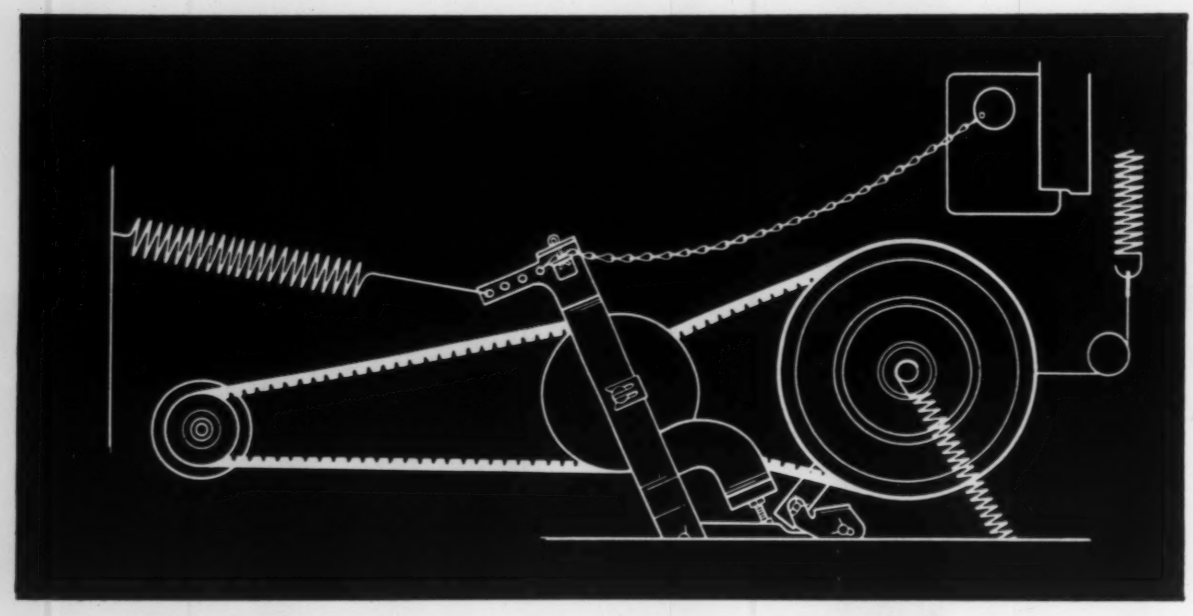


FIGURE 1—RCA WHIRLPOOL Washer-Dryer Combination with back panel removed showing variable speed drive controls.

The final design, now in production, (Fig. 1) employs a simple, single-speed motor to drive the cylinder at both tumble and spin speeds and completely eliminates the conventional geared transmission. Essentially, the drive is composed of a unique variable speed sheave assembly and two plate-finished Dayton Variable Speed Cog-Belts.

The sheave assembly (Fig. 2) has a sliding center section, and is mounted in a pivoted bracket. Movement of the bracket, and control of the speed ratio, is through a speed control motor connected to the bracket by a chain.

During all wash, rinse and tumbling cycles (Fig. 3), the sheave assembly is held in low drive by a pull-back spring.

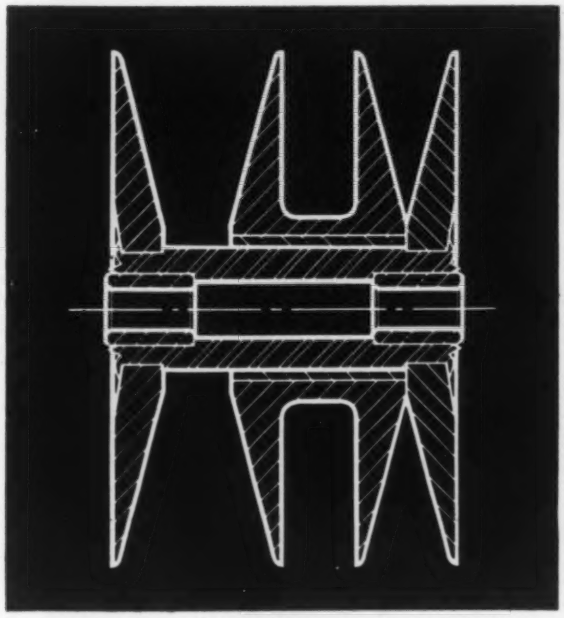


FIGURE 2
Exploded view of variable speed sheave assembly.

Cylinder speed during the low drive cycles is 45 rpm.

During the spin-dry cycle (Fig. 4), the speed control motor is actuated and, by taking-up the linking chain, causes the bracket to pivot. As the bracket moves, tension is increased on the primary belt and decreased on the secondary belt, causing the center section to move sideways. As tension is equalized by the movement of the center section of the sheave, the primary belt pulls deeper into the sheave and the secondary belt is forced away from the sheave axis. The ratio change thus effected produces a resultant speed of 200 rpm.

Another tremendous advantage of the design is that it is infinitely variable within the assigned limits. Thus, it is possible, by the addition of a delayed-reset switch and a simple control arm, to interrupt the speed change at any point, if vibration is created by an out-of-balance load. The result is positive, automatic load balancing.

Here is how this feature operates. When an excessive out-of-balance condition exists, the excursion switch arm trips the excursion switch. This breaks the circuit to the speed control motor for approximately 13 seconds — during which time the pull-back spring returns the drive to tumble speed and the load redistributes itself. When 13 seconds have elapsed, the switch automatically resets and the drive again shifts into the high range. If necessary, there can be unlimited "hunting" for a balanced condition before the cylinder reaches 200 rpm, the normal spin-dry speed.

While complex and difficult to describe, the load balancing operation is so smooth that it is hardly perceptible. This is due to the special design and construction of Dayton Raw-Edge Cog-Belts.

Dayton's experienced Engineers are ready to assist you in solving your special V-Belt design problems. To contact them, or for more information about Dayton Raw-Edge V-Belts, write The Dayton Rubber Company, Industrial O.E.M. Division, Dayton 1, Ohio.

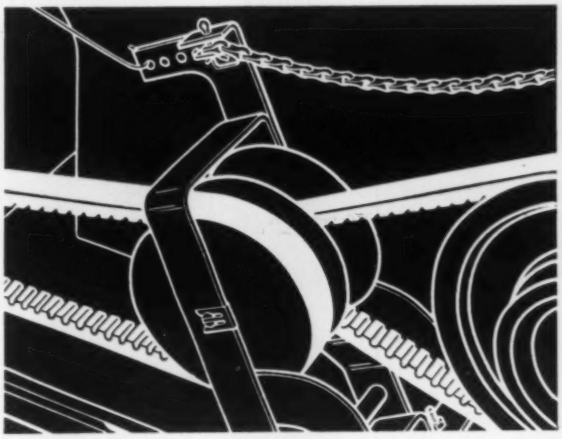


FIGURE 3
Variable speed drive during tumble cycle. Cylinder speed is 45 rpm.

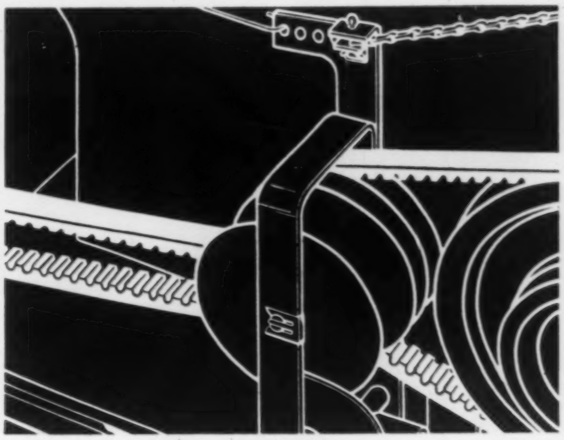


FIGURE 4
Variable speed drive during spin cycle. Cylinder speed is 200 rpm.

THE DAYTON RUBBER COMPANY, INDUSTRIAL O. E. M. DIVISION, DAYTON 1, OHIO

Dayton Rubber *T.M.

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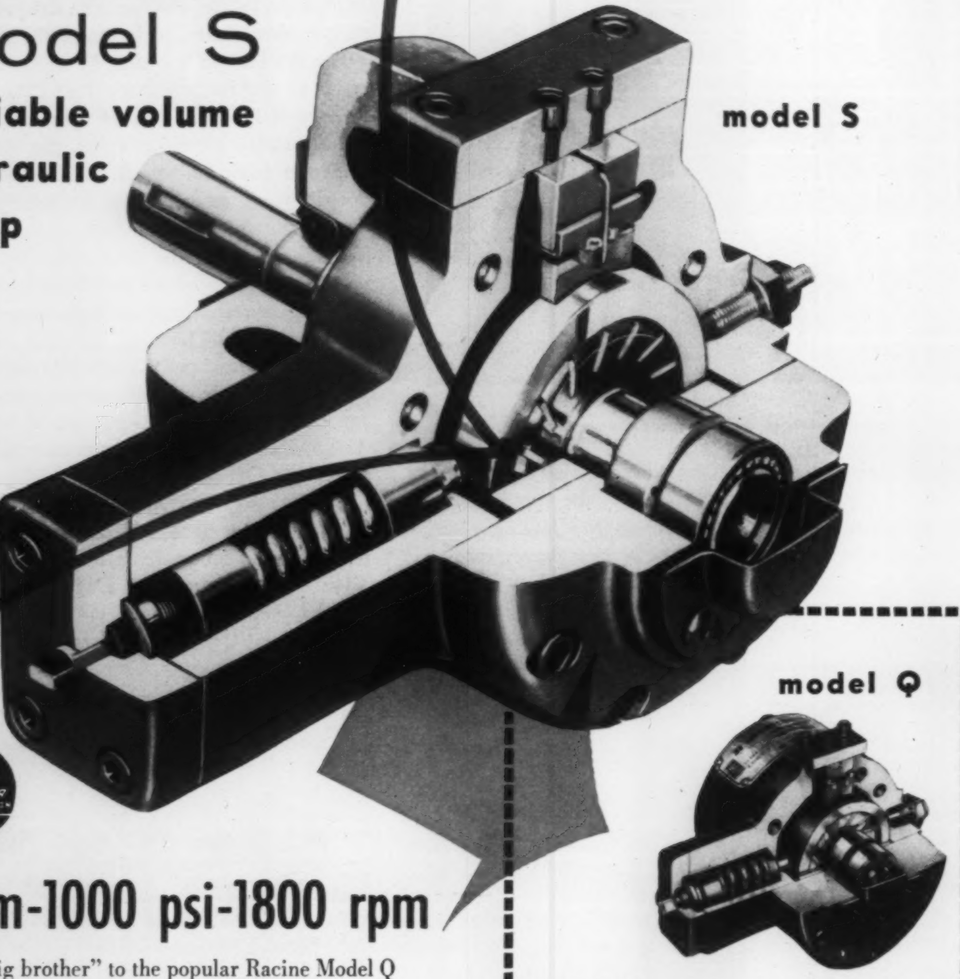
WORLD'S LARGEST MANUFACTURER OF V-BELTS

Industrial Sales Engineers in Atlanta, Chicago, Cleveland, Dallas, Dayton, Minneapolis, Moline, New York, San Francisco and St. Louis

Circle 455 on Page 19

new!

RACINE
Model S
variable volume hydraulic pump



NATIONAL FLUID POWER ASSOCIATION
Member

10 gpm-1000 psi-1800 rpm

Here is the "big brother" to the popular Racine Model Q (5 gpm-1000 psi) pump. Both of these pump models answer the needs of builders of quality equipment for accurate control with extremely high circuit efficiency.

Compact design — only 7⅛″ long, 6″ wide and 4¾″ high, makes the Model S ideal for use in areas where space conservation is essential.

When Racine-Seco pumps are used in combination, specifications of 1-1/2 gpm to 70 gpm at pressures up to 10,000 psi are available.

Write for brochure PB-2 which contains complete descriptive literature. Take advantage of Racine's FREE engineering service.

VARIABLE VOLUME *Racine variable volume principle steps up production by extending tool life and increased overall machine efficiency. Saves horsepower.*

CONTROL *A built-in volume control provides adjustment of pump displacement for exact circuit requirements — a feature that reduces motor size.*

GOVERNORS *Both the standard Model S and Model Q utilize the Racine pressure compensating governor. Special governors and governor springs are also available. No relief valves necessary.*

MOUNTING *Standard JIC subplate design for simple installation and maintenance.*

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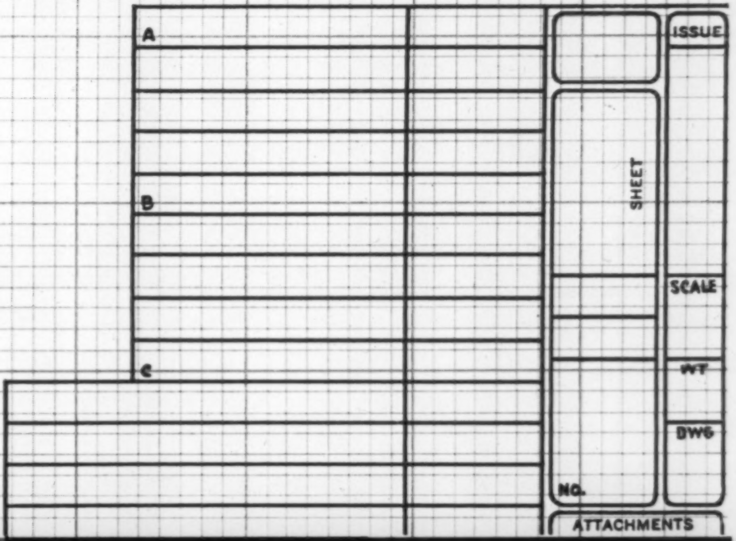
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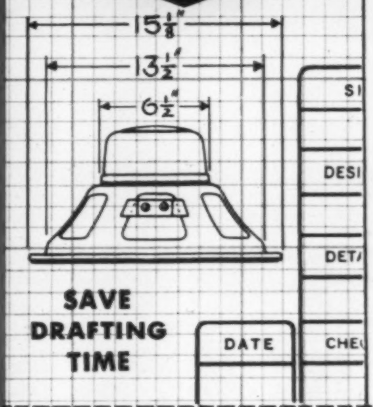
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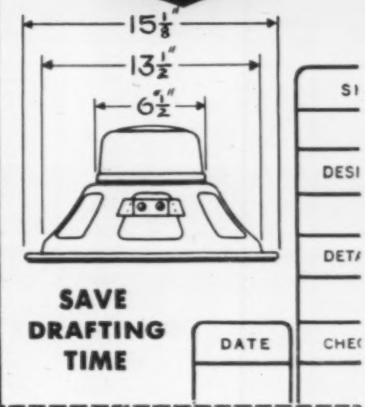
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Circle 457 on Page 19

Here's what Morse's entry into the "Timing"® Belt field means to you . . .

Nobody gives you a more impartial analysis of your power transmission problems than Morse, because . . . *only Morse* offers all four of these basic drives plus a complete line of power transmission products

Basic Drives: Roller Chain, Silent Chain, Hy-Vo® Drives, and "Timing"® Belt.

Chain: High-Endurance (H-E), 8-series (Super Strength), Double-Pitch, Conveyor, Implement, and Attachment; AL, BL, Cable Chain, and Rollerless Lift Chain; Industrial Standard and 3/16" Silent Chain.

Stock Sprockets: Plain Bore, Finished Bore, Taper-Lock—also made to order.

"Timing" Belt Sprockets: Plain Bore, Taper-Lock, Q.D.—also made to order.

Couplings: Flexible Roller Chain Couplings, Flexible Silent Chain Couplings, Morflex Couplings, Morflex Radial Couplings, and Marine Couplings.

Driveshafts: Morflex and Radial Driveshafts.

Clutches: Cam (Over-Running, Back-Stopping, Indexing); Pullmore; Over-Center, Centrifugal.

Speed Reducers: Eberhardt-Denver "RW" poweR-gear® Reducers; Gear Motors; "L" Worm Gear Reducers; "VX" and "DVX" Conveyor Drives; Miter Boxes; Helical Reducers.

Torque Limiters.

Look for your local Morse distributor in the Yellow Pages under "Power Transmission," or write:

MORSE CHAIN COMPANY, DEPT. 6-28, ITHACA, N. Y. Export Sales: Borg-Warner International, Chicago 3, Ill.

1
2
3
4
MORSE
B-W

1. **"Timing" Belt** . . . for light weight and lubrication-free operation. Morse "Timing" Belts give positive, high-efficiency transmission from 0 to 16,000 FPM, 1/100 HP to 1,000 HP . . . provide slip- and stretch-proof service for life of drive.

2. **Roller Chain** . . . for low and medium speed applications. Precision-finished Morse Roller Chain is specially treated to withstand shock and fatigue, assure less maintenance, longer service life. Patented Spirol Pin Fastener construction.

3. **Silent Chain** . . . for smoother, quieter operation at higher speeds. In Morse Silent Chain the patented rocker joint operates with less friction and wear. It provides a cooler-running chain drive, with higher efficiency and longer service life.

4. **Hy-Vo Drive** . . . for extremely high speeds and horsepower. Exclusive with Morse, extra-tough Hy-Vo Drives transmit mile-a-minute speeds, and up to 5,000 hp loads; require minimum shaft space, usually eliminate outboard bearings.

IN POWER TRANSMISSION
THE TOUGH JOBS COME TO

MORSE

MORSE
B-W
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Plants in: Ithaca, N.Y., Detroit, Mich., Chicago, Ill., Denver, Colo., Simcoe, Ont.

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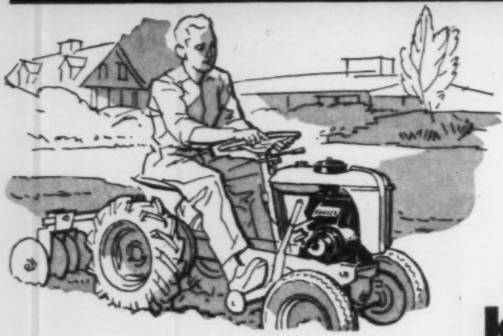
Circle 458 on Page 19

KOHLER ENGINES

4-CYCLE
SHORT-STROKE
AIR-COOLED



MODEL
K160

IN Action

MODEL
K90

- Efficient and reliable
- Short-stroke gives more usable power, cuts engine friction
- Hot spark assures quick starting in all weather
- Balanced crankshaft—ball bearings reduce vibration
- Rugged construction — plenty of load-lugging power
- Kohler engines will do the jobs for which they are recommended

FROM 3 TO 24 H.P. *Send for 28-page illustrated booklet.*

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Enameled Iron and Vitreous China Plumbing Fixtures • Brass Fittings • Electric Plants • Air-cooled Engines • Precision Controls

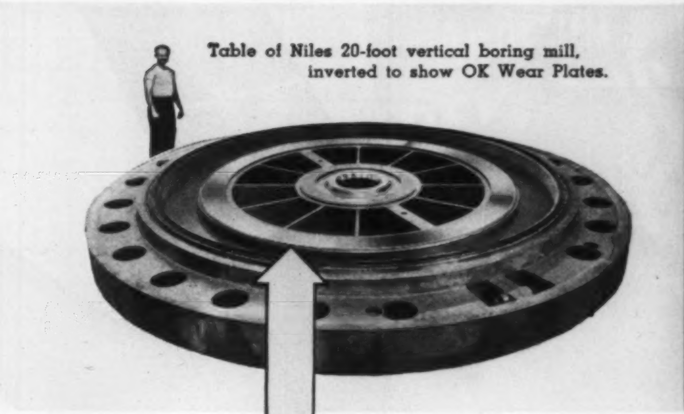
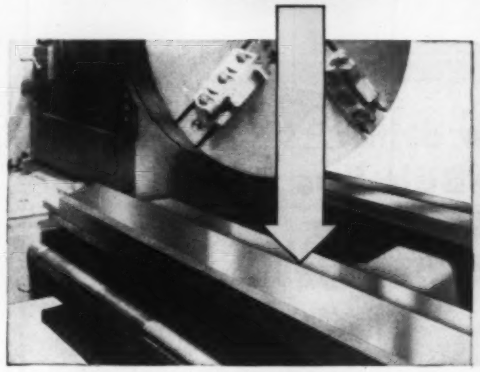
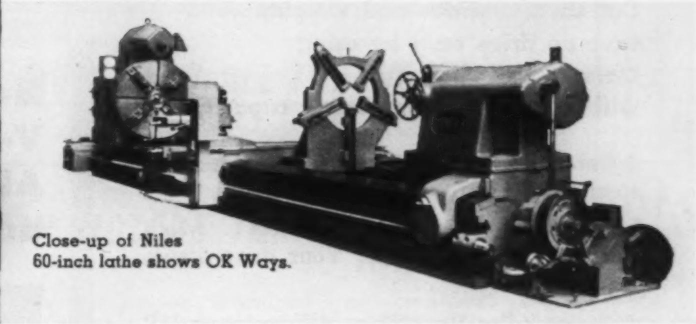


Table of Niles 20-foot vertical boring mill, inverted to show OK Wear Plates.

good ways to keep customers happy





Close-up of Niles 60-inch lathe shows OK Ways.

THE NILES TOOL WORKS . . . of the Baldwin-Lima-Hamilton Corp., is one of many U. S. machine tool builders using OK Hardened Ways and Wear Plates. Their mammoth machine tools require ways and wear plates that maintain absolute accuracy for the life of the machine. OK Ways and Wear Plates are used because our unique manufacturing and hardening processes make them virtually wear-proof.

Special-analysis tool steel is welded to a soft steel backing, resulting in a work surface of high wear-resistant properties. This process permits manufacture in long lengths without danger of bowing or warping.

Hardening is done in electronically-controlled furnaces, giving a ROCKWELL C 64-66 the full depth (normally 3/16") of the tool steel. They are precision ground to tolerances of ± .0002" with low micro-inch finish.

Make your customers happy. Insure trouble-free operation of your machines with OK Ways and Wear Plates (also available in clad aluminum bronze). Our engineering staff will assist you in your design or production problems.

For free bulletin showing seven standard cross sections in over 60 sizes, write Dept. 41-A

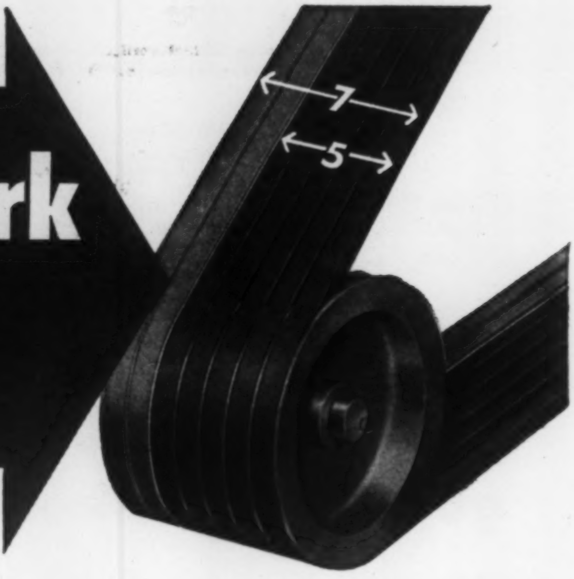
THE OHIO KNIFE CO.

CINCINNATI 23, OHIO

Hardened Ways
Slitter Knives
Shear Blades
Cut-Off Blades
Hardened Spacers
Gibs
Ball Races
Work-Rest Blades
Wear Strips
Bronze Ways

Circle 460 on Page 19

5 do the work of 7



Cut sheave width and weight; save on drive costs by using Gates Super Vulco Ropes with 40% *more horsepower capacity.*

5 Gates Super Vulco Ropes do the work of 7 standard V-belts.

Sheaves with fewer grooves cost less . . . weigh less . . . occupy less space. Your drive design is improved.

A Super Vulco Rope Drive delivers more HP per dollar invested than any standard V-belt drive.

Helpful drive data is quickly available to you. Simply call your nearby Gates distributor for a Gates V-belt specialist. Stocks carried in industrial centers throughout the world.

The Gates Rubber Company
Denver, Colorado
World's Largest Maker of V-Belts.

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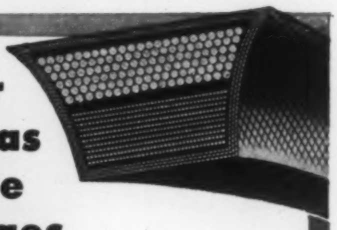
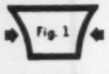
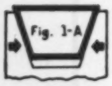
Gates — The Mark of *Specialized* Research

No other V-Belt has ALL these advantages

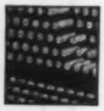


1. Flex-Weave Cover (U.S. Pat. 2519590)
A Gates exclusive: provides greater flexibility with far less stress on fabric. Cover wears longer . . . increases belt life . . . more power available to driven machine.





2. Concave Sidewalls (U.S. Pat. 1813698)
Concave sides (Fig. 1) increase belt life. As belt bends, concave sidewalls become straight, making uniform contact with sheave groove (Fig. 1A). Uniform contact means less wear on sides of belt . . . far longer belt life.



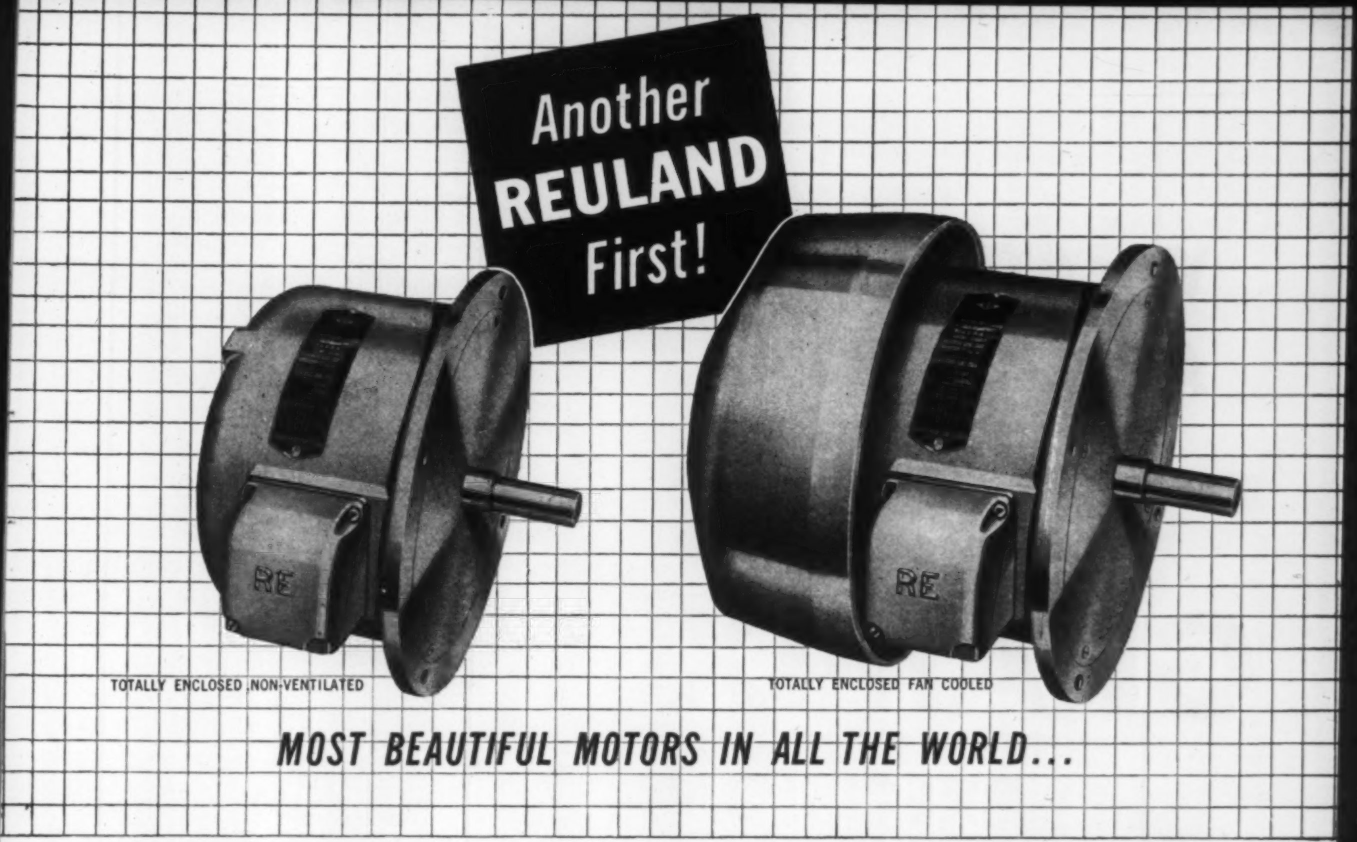
3. Tough, resilient tensile Cords
Super-strong resilient tensile cords provide 40% greater horsepower capacity . . . easily absorb heavy shock loads . . . reduce number of belts required . . . save weight and space.

4. High Electrical Conductivity
Built into Gates Super Vulco Ropes for safer drives (in explosive atmospheres).

5. Oil, Heat, Weather Resistant
Special rubber compounds make Super Vulco Ropes highly resistant to heat, oil, and prolonged exposure to weather.

Gates Super Vulco Rope Drives

40% more Horsepower Capacity


Another
REULAND
First!
RE
RE
TOTALLY ENCLOSED NON-VENTILATED
TOTALLY ENCLOSED FAN COOLED
MOST BEAUTIFUL MOTORS IN ALL THE WORLD...

NEW REULAND PRECISION MOTORS FOR MACHINE TOOLS

Designed especially for machine tool manufacturers

Reuland precision motors were developed only after giving a lot of careful thought to the problems of the machine tool industry. They are not just another line of motors that can be "made to fit," but rather, a complete new type especially made for machine tool manufacturers.

They are available in T.E.N.V. and T.E.F.C. types. Small, compact and featuring the very latest in lightweight materials.

For good looks and precision operating characteristics, there is nothing on the market to equal these jewel-like units.

Precision balance

Reuland motors are built to precise specifications like a fine tool. Each unit is dynamically balanced at the factory to assure vibrationless operation.

Heavy-duty ball bearings, located at each side of the rotor, assist in maintaining this characteristic which is so vital to precise work. Exact tolerances are likewise maintained throughout final assembly.

Low inertia rotor

The radial air gap design of these motors permits the use of a lighter weight, low inertia rotor. This light weight, low inertia feature assures smooth starts and quick stops.

This rotor is also of a special narrow design which has shortened up the overall length of the motor to give a thinner, "wafer" effect.

Smooth-finished castings —pleasing lines

The smoothly finished surfaces of Reuland machine tool motors are a match for the most expensive tool. All castings are specially processed for smoothness and are given a baked enamel finish.

This fine-quality finish, together with the motors' naturally pleasing lines, assure a harmonious blend with the lines of every machine tool on which they are mounted. (When desired, the motor's frame size can even be varied to fit an *exact* contour of the machine.)

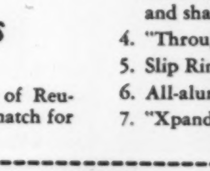
Other Reuland firsts!

1. Motor with internal fluid coupling
2. Spline-coupled hydraulic pump motor
3. Foot-mounted disc type magnetic brake with self-contained bearings and shaft
4. "Through-Shaft" magnetic disc brakes
5. Slip Ring motors in small #66 frames
6. All-aluminum motor frames
7. "Xpandable" motor design

Use these other free Reuland Services

Special-Motor Library

Don't ever pay for special-motor development costs before you check this free library. Contains valuable data on hundreds of unique, specially designed motors. Send for free "how to use" booklet.



Standard Motor Catalog

Contains engineering information on Reuland's complete line of standard motors and motoreducers. Sent free on request.

REULAND MOTORS

REULAND ELECTRIC COMPANY
Western Division: Alhambra, California
Eastern Division: Howell, Michigan
Distributors in all principal cities

Circle 462 on Page 19

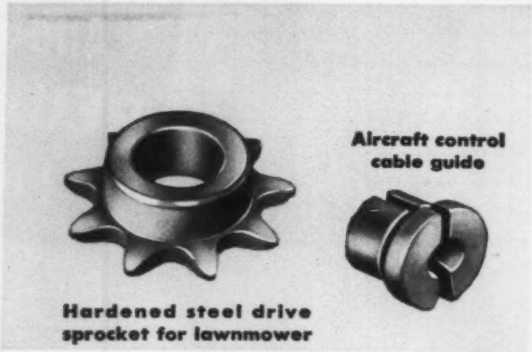
WHATEVER THE APPLICATION...

you can improve your product with

GRAMIX®

(PRODUCT OF POWDER METALLURGY)

PRECISION FINISHED PARTS


Aircraft control cable guide

Hardened steel drive sprocket for lawnmower

Self-aligning guide bearing for industrial blower shaft

GRAMIX precision finished parts are improving products in virtually every branch of industry. A pump manufacturer, for instance, may specify a gasoline pump rotor made of GRAMIX and gain a number of advantages.

To begin with, the alloys are carefully blended to meet his individual requirements. The GRAMIX parts are then die-pressed to exact shape, sintered under rigid control and finished to tolerances as close as .0005". (This process, of course, costs far less than machining, forging or casting.) The manufacturer can expect the GRAMIX gasoline pump rotor to do a better job because *all* GRAMIX parts are precision engineered and precision controlled from alloying to finishing.

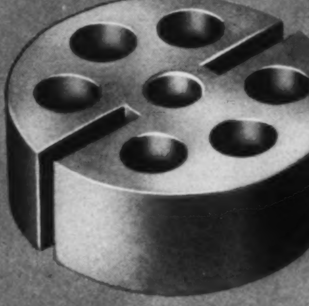
No matter what the application may be, GRAMIX parts fit specifications exactly. Parts may be impregnated with oil ... to insure a longer life and a quieter operation: if specified, the GRAMIX parts may be coined and work hardened, even prepared for plating.

The rotor is only one of thousands of applications in which GRAMIX precision finished parts have proved to be ideal. Just a few of them are shown here, so consider the components of your products ... there may be several that could be improved ... with GRAMIX! Products of powder metallurgy you can rely on.

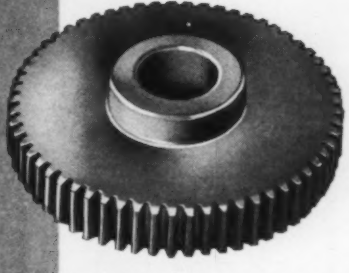
METALLURGY PARTS MANUFACTURERS ASSOCIATION
POWDER
MEMBER

THE UNITED STATES

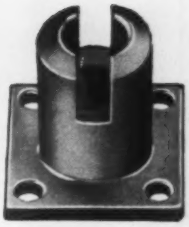
GRAPHITAR® CARBON-GRAPHITE • **GRAMIX®** POWDERED METAL PARTS • **MEXICAN®** GRAPHITE PRODUCTS • **USG®** BRUSHES



Automotive compressor rotor

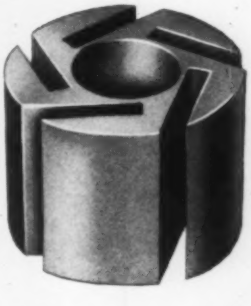


Infiltrated iron gear
for lawnmower



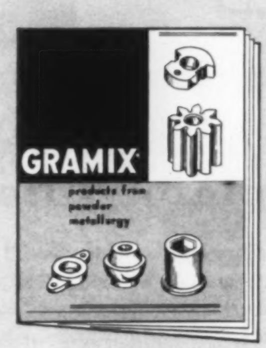
Iron switch control

Iron clutch segment



Rotor for gasoline pump

Packing gland follower used
in hydraulic system



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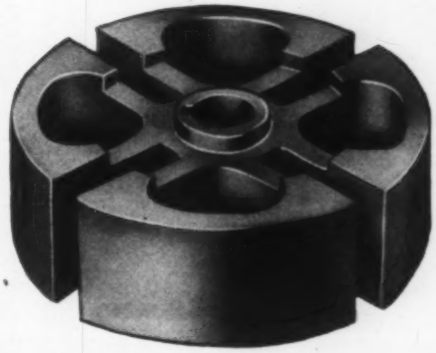
Write today for factual Engineering Bulletin No. 21 . . . we'll send your copy right along.



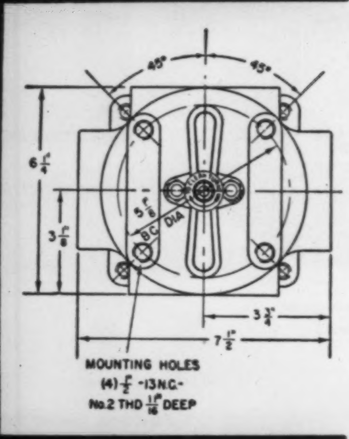
Bronze rotor in high speed fueling unit

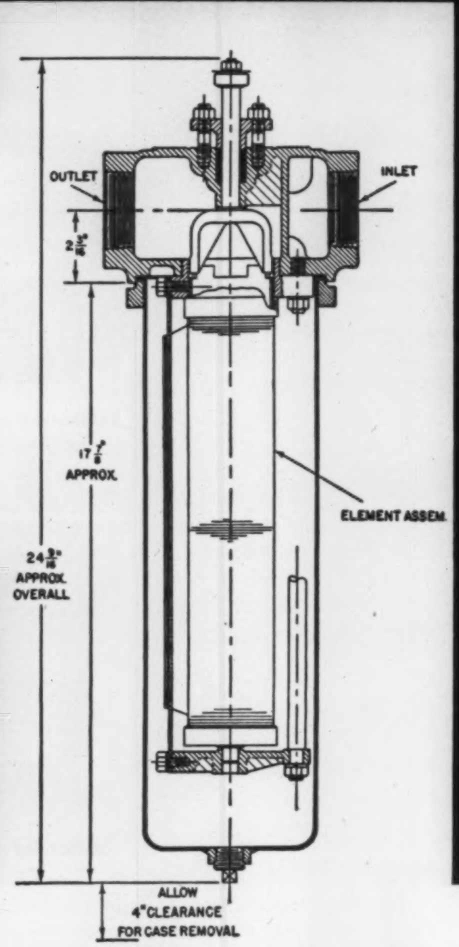
X-253-1

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

Circle 463 on Page 19


45°
45°
6 1/4"
3 1/8"
5 7/8" BC DIA
3 3/4"
7 1/2"
MOUNTING HOLES
(4) 1/2" -13N.C.-
No.2 THD 1 1/16" DEEP


OUTLET
INLET
2 5/16"
17 7/8" APPROX.
24 3/16" APPROX. OVERALL
ELEMENT ASSEM.
ALLOW 4" CLEARANCE FOR CASE REMOVAL

Your "special" filtration problems can be solved by standard Purolator filters

FOR EXAMPLE...This one standard Purolator filter is exactly right for all these "special" filtration problems:

inks, paints,
varnishes, machine tool coolants,
greases, vitamin solutions,
as well as fuel and lube oils.

This filter's specifications may recommend it for a problem of yours. If not, you're almost certain to find a standard Purolator filter that does meet your needs—exactly.

SPECIFICATIONS...This is Purolator filter model G-141J with simplex full flow metal element oil strainers. It is designed for primary or first stage filtration and can be installed on pressure or suction side of pump. Recommended for maximum capacities of 40 to 80 GPM, dependent on spacing which varies from .003 to .010. Relief valves set from 10-12 to 50 PSI are incorporated in several models. Motor driven knife blade to clean element can be furnished whenever conditions make manual rotation impractical. Head is made of high tensile cast iron, body of drawn steel. Inlet and outlet connections are 2", drain plugs are provided. Maximum pressure: 125 PSI; weight: 37 lbs.

Remember, if these specifications don't match your needs, there's probably a filter that does at Purolator. Find out. Send in your problem.

Filtration For Every Known Fluid

PUROLATOR
PRODUCTS, INC.
Rahway, New Jersey and Toronto, Ontario, Canada

Circle 464 on Page 19

QUALITY
TUBE
from
Brainard
starts with
SHARONSTEEL
BRAINARD
SHARON STEEL

From mine to finished product, Brainard Welded Steel Tubing has that extra quality that comes only from integrated industry. Brainard Welded Steel Tubing has this extra advantage. Quality controlled from blast furnace to your receiving dock, Brainard can match your most exacting specifications.

For complete information on Brainard's Welded Steel Tubing, send for this all new catalog.

Brainard Steel Tubing
Griswold St. Ext., Warren, Ohio

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Address: ________________

City: ________ Zone: ____ State: ________

Brainard Steel Tubing

SHARONSTEEL

622

Brainard Steel Division, Sharon Steel Corporation
Griswold Street, Warren, Ohio

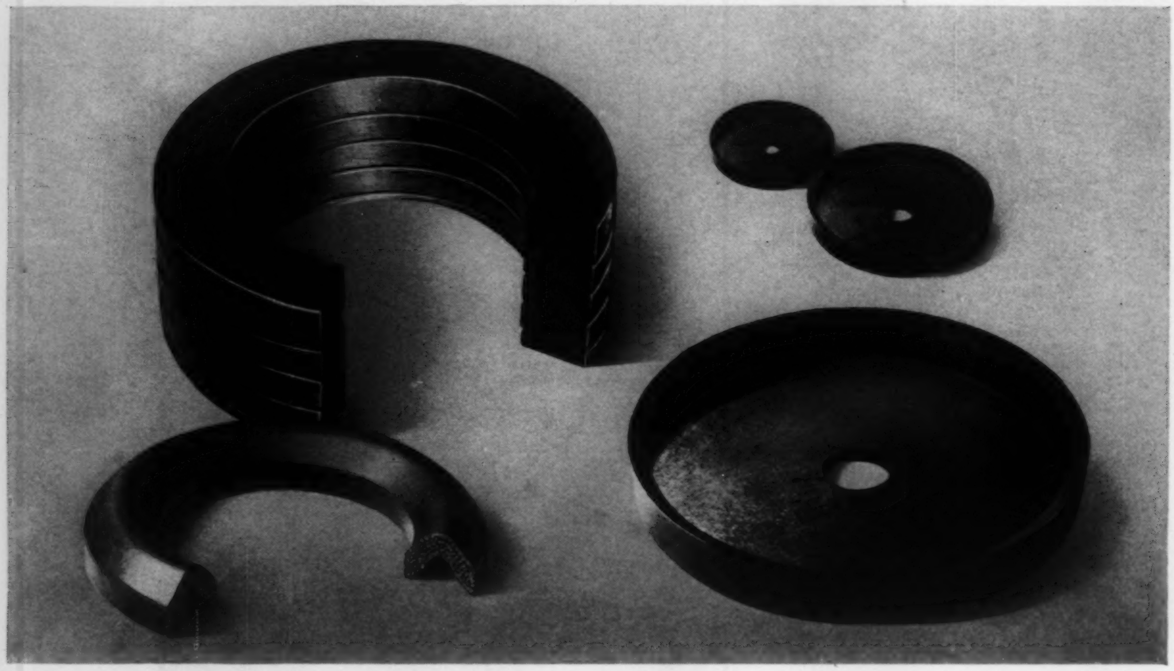
Circle 465 on Page 19

CUT COSTS, IMPROVE DESIGN AND PERFORMANCE WITH R/M PRODUCTS

PACKINGS

Complete information on packings shown and many others is given in free booklet. Send for it today.

Packing Division, Raybestos-Manhattan, Inc.
Passaic, N.J.



R/M Vee-Flex Rings seal automatically and will not roll. R/M Fabric Piston Cups are precision molded and cleanly trimmed.

Precision quality control means you can rely on R/M V-rings and piston cups

R/M Vee-Flex Rings give better performance and cut maintenance costs. Convex curvature of the surface which touches next ring makes them self-sealing, self-adjusting. Pressure stroke produces a seal against stuffing box wall and adjacent ring. Friction is reduced on return stroke. Precision molded and trimmed for best possible fit. Fabric is deeply penetrated by compound for longer wear. Use them on steam or air rods, hot oil pumps, hydraulic rams, outside-packed plunger pumps, food handling machinery, accumulator and elevator rams on oil or water service.

R/M Fabric Piston Cups provide minimum friction, long life, and accurate fit. Molded from a variety of rubber synthetics with fabric reinforcements to suit your specific requirements. See the big difference: clearly defined contours and cleanly trimmed edges—proof of strict adherence to industry standard sizes. R/M Fabric Piston Cups fit hydraulic and pneumatic cylinders ranging in diameter from ½ to 12 in. They are produced in varying degrees of hardness for pressures up to 1500 psi and in compounds to meet your specific operating conditions.

The complete R/M line includes packings and gasket sheets for use with gases, water, steam, oil, chemicals, solvents and food products. Feel free to call on R/M's experienced engineers for help in your packing problems.

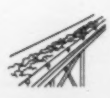
Brake Blocks, Linings and Clutch Facings

Mechanical Packings and Gaskets

Abrasive and Diamond Wheels

Industrial Drive Belts

Industrial and Automotive Hose



Conveyor Belts

SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METAL, ENGINEERED PLASTICS

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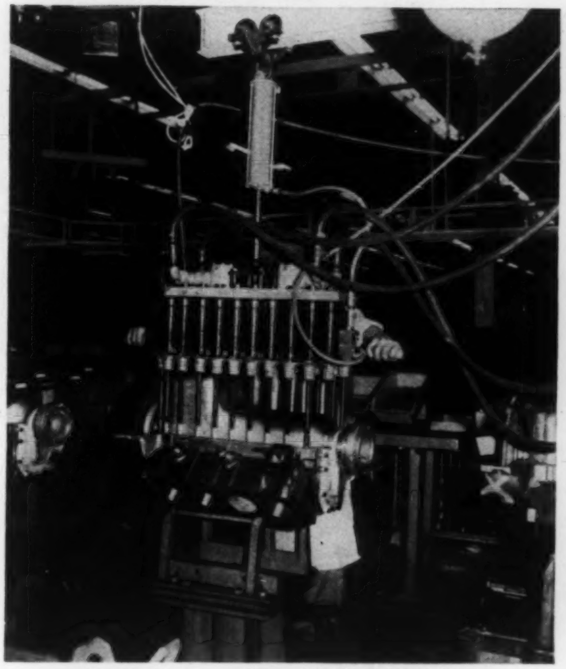
Write today for free booklet shown: full details on a wide variety of industrial rubber products.
Manhattan Rubber Division, Raybestos-Manhattan, Inc.
Passaic, N.J.

PLASTICS

Write for free booklet, which provides valuable information on a variety of R/M plastic products.
Plastic Products Division, Raybestos-Manhattan, Inc.
Manheim, Pa.



Homoflex Hose, manufactured by Manhattan Rubber Division, is engineered for use on air-driven tools.

R/M Hose engineered for many purposes

For general use with air, water, gases . . . special types for handling oils, acids, chemicals . . . or non-spark, high heat or non-contaminating construction—R/M has a rubber hose for *every* application.

For example, *Flexlon* R/M rubber hose, "Teflon"* lined, offers complete resistance to virtually all chemicals and solvents. *Allflex* is a versatile all-purpose hose for handling fluids and gases—even mild chemicals. *Homoflex*, lightweight and easily handled, is ideal for air tools. *Super-Master BW* Burstproof Steam and Air Hose has special wire braid reinforcement for rugged, high pressure service.

R/M also makes flanged flexible pipe and rubber expansion joints. Whether it's hose, transmission or conveyor belts, V-belts, Poly-V Drive® or molded rubber products, depend on R/M's 60 years of leadership in rubber.

"Teflon" diaphragms protect Salk vaccine from contamination during long manufacturing process.

R/M "Teflon" Valve Diaphragms protect purity of polio vaccine

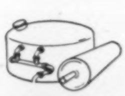
Salk polio vaccine must be kept absolutely pure and sterile during the 130 days needed to manufacture and test it. To help guard against contamination, valves are sealed with thin, long-lasting diaphragms of "Teflon," developed by Raybestos-Manhattan. "Teflon" is ideally suited for this exacting application. It is strong, flexible, chemically inert, easily sterilized, and well able to withstand the required temperatures, ranging from 5 to 150°C.

Many other R/M "Teflon" products are also at work for aviation, missile, electrical and electronic industries. Among these are flexible thin-wall tubing (plain or covered); tape; custom-machined parts; rods and gaskets; expansion joints and flexible couplings; bondable "Teflon" sheet and other products. Raylon, an R/M mechanical grade of "Teflon," has many of the characteristics of virgin "Teflon."

*A Du Pont trademark

RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn • Manheim, Pa. • Paramount, Calif. • No. Charleston, S.C.
Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada



Rubber Lined and Covered Equipment

Sintered Metal Friction Elements

Asbestos Textiles

Industrial Adhesives

Teflon Tape, Packings, Sheets, Rods, Tubes

Engineered Molded Rubber and Plastics

R/M

Circle 466 on Page 19

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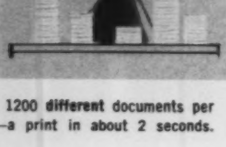

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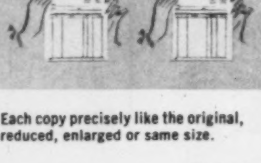

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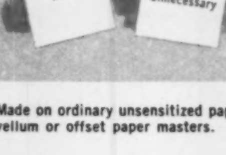

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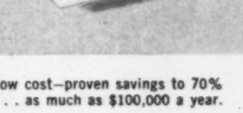
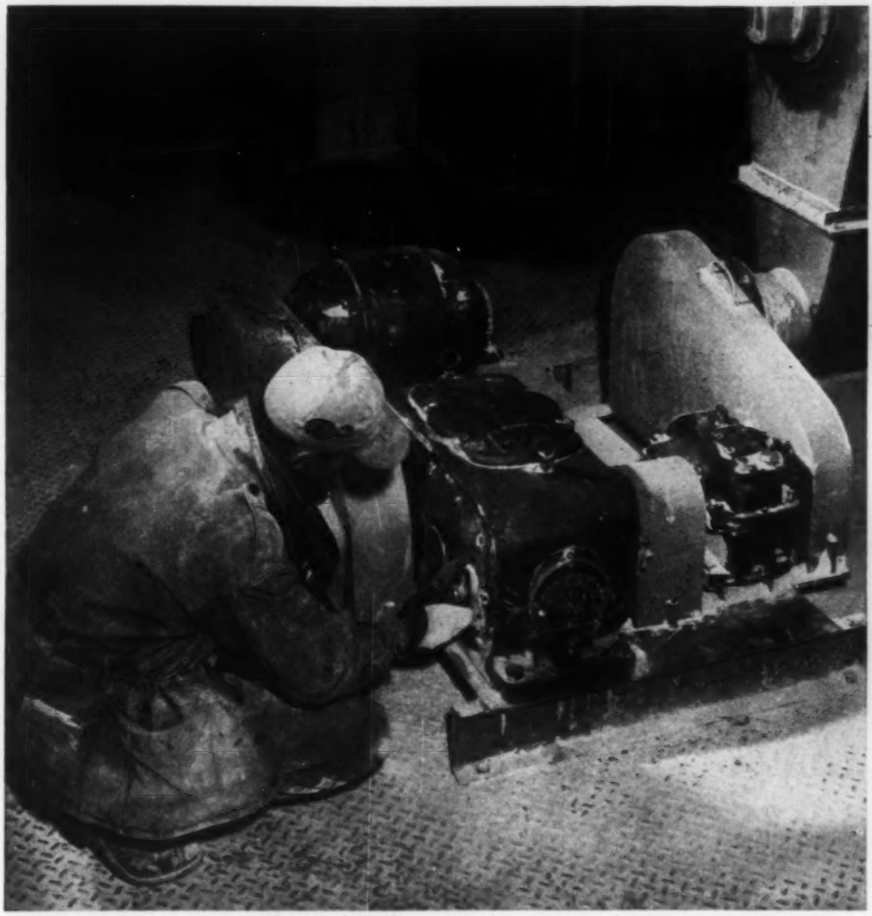


Low cost—proven savings to 70% . . . as much as $100,000 a year.

Circle 467 on Page 19



INSTANT SPEED CHANGING. To get desired output rpm, operator simply turns handwheel to desired position on easy-to-read dial. P.I.V. responds instantly, accurately. Drives are also available with automatic, electric, pneumatic or hydraulic controls.

SELF TOOTH-FORMING CHAIN consists of a series of steel laminations, serving as teeth, which are free to move from side to side, either singly or collectively.

RADIALLY GROOVED WHEELS have teeth cut at constant depth but of increasing width toward wheel periphery. Beveled sides of teeth provide gripping surfaces for chain.

Slipless transmission - - stepless selection

That's because LINK-BELT P.I.V. uses self-tooth-forming chain

LINK-BELT P.I.V.—unlike other variable speed drives—incorporates an exclusive metal, self-tooth-forming chain to give you instant, positive speed variation, regardless of load. This unique drive permits infinitely variable speed changes without loss of accuracy or interruption of operations. That's why P.I.V. is all industry's choice for jobs requiring stepless, slipless power transmission.

Changing speed is simple too. A turn of the control screw simultaneously varies the effective diameters of two sets of conically shaped wheels—closing one set, spreading the other. At the same time, the self tooth-forming chain automatically adjusts to provide desired ratio between the input and output shafts.

Link-Belt P.I.V drives are fully enclosed for trouble-free operation. They're splash-lubricated for long life—unaffected by atmospheric conditions. Choose from 8 sizes in 16 standard types, with the aid of Book 2274. Call your nearby Link-Belt office for complete information.

74 314 A

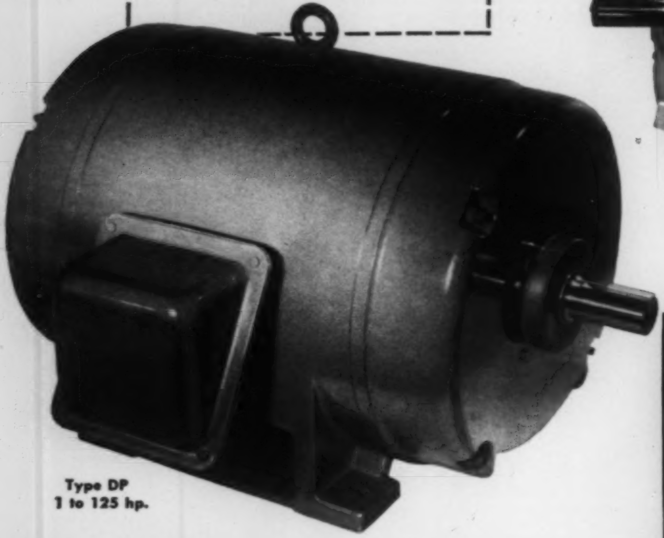
LINK-BELT

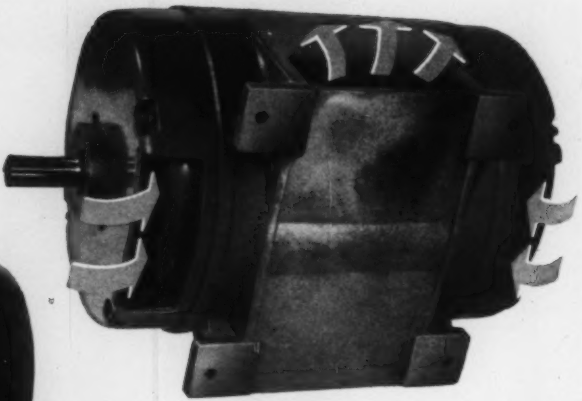
P.I.V. VARIABLE SPEED DRIVE

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World.

Circle 468 on Page 19

WAGNER
POLYPHASE
MOTORS


Type DP
1 to 125 hp.



These open type motors give DOUBLE PROTECTION... can be used in many places that formerly required splashproof motors

Wagner Type DP Motors offer the *double protection* of rugged corrosion-resistant cast iron frames and dripproof enclosures so well designed that the DP Motor can handle many applications that formerly required splashproof motors.

These Wagner Motors are built in the new NEMA ratings that pack more power into less space, are lighter in weight and are easier to maintain—only occasional lubrication is required.

SLEEVE BEARING MODELS AVAILABLE

The entire line of ratings through 125 hp. is available with steel-backed, babbitt lined sleeve bearings that have high carrying capacity and provide quieter operation.

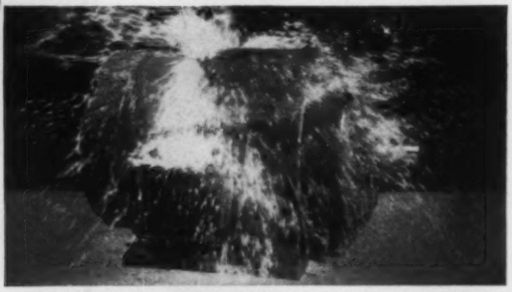
Let a Wagner Sales Engineer show you how these motors can be applied to your needs. Call the nearest branch office or write for Wagner Bulletin MU-223.

1 to 125 HP—1750 RPM—40°C NEMA FRAMES 182 through 445U

Wagner Electric Corporation
6404 Plymouth Ave., St. Louis 14, Mo., U. S. A.

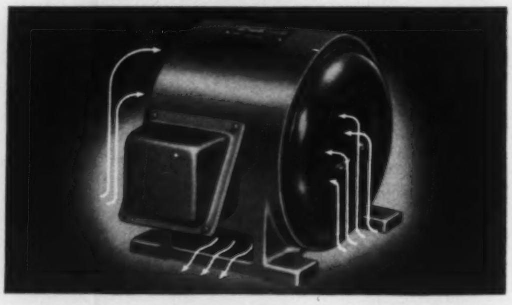
WH58-4

SEE OUR EXHIBIT—DESIGN ENGINEERING SHOW—BOOTH 558



DOUBLY PROTECTED – Wagner DP Motors offer the *double protection* of completely dripproof enclosures and rugged cast iron frames that can take rough handling and resist corrosion.

CAN BE RELUBRICATED – These motors can be re-greased when desired for longer bearing life. Fresh grease can be added—old grease removed—through openings provided in the ball bearing housing.



COOL RUNNING – Specially designed baffles direct cooling air through the motor to protect the stator windings. Blowers, cast as part of the rotor, move large volumes of air without noise or vibration.

Circle 469 on Page 19

New ASCO 3-Way Solenoid Valve assures MILLIONS OF TROUBLE-FREE OPERATIONS

NO EQUAL IN SIMPLICITY!

Simplicity is the secret of this remarkable, new 3-way diaphragm valve. It has *only three operating parts.* Compare this with the larger number of parts found in conventional 3-ways! That's one reason why the new ASCO valve means trouble-free operation . . . substantial savings in maintenance costs . . . reduction in down-time losses.

The EXTRA HEAVY FORGED BRASS BODY houses only three moving parts: Two diaphragms and a core. Corrosion protection is assured. All parts in contact with fluids or gases are brass, stainless steel or Buna-N.

SIMPLICITY IN OPERATION

Not only its construction but also its new operating principle is the essence of simplicity: solenoid piloting of two simple diaphragms.

UP TO 400 CYCLES PER MINUTE

Exceptionally large flow capacity makes rapid recycling feasible . . . cylinders fill and vent rapidly . . . valve operates up to 400 cycles per minute over millions of strokes.

CONVERTS IN 30 SECONDS

Developed for dependable control of liquids and gases, the valve can be converted from normally open to normally closed or the reverse by simple rotation of the valve bonnet.

This new valve is absolutely tight seating . . . no closely fitted parts or valve seat grinding required. Available now in 3/8″ and 1/2″ pipe sizes, both with full 3/8″ orifices, it can be mounted in any position.

WRITE NOW for your copy of ASCO Bulletin 8316, or have the ASCO Engineer call.

ASCO

DEPENDABLE CONTROL

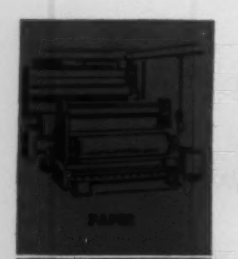
Automatic Switch Co. • 54-A HANOVER ROAD • FLORHAM PARK, NEW JERSEY

AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

Circle 470 on Page 19

DYNAMATIC®

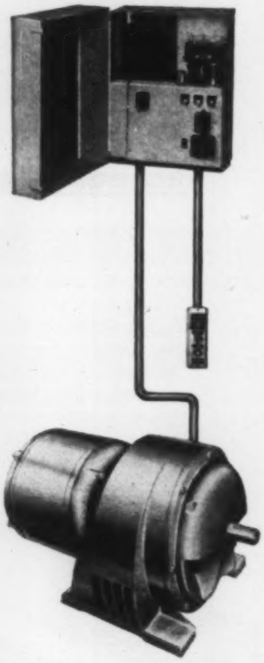
Eddy-Current and Solving Problems



AUTOMOTIVE

MINING EQUIPMENT

If you want to Drive, Stop, Test—Control Speed, Torque, or Tension — Dynamatic Equipment will do it Better at Lower Cost!



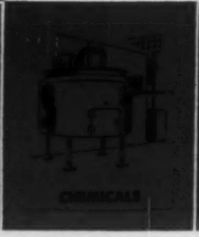
Dynamatic Eddy-Current Couplings, Drives, Brakes, and Dynamometers—

fulfill practically all stepless adjustable speed and testing equipment requirements, using standard alternating current as a power source. This Dynamatic torque transmitting equipment, with electronic or magnetic amplifier control, offers a long list of outstanding advantages: rapid response, wide speed range, quiet operation, low power loss, low maintenance cost, and remote control. There are types and sizes of Dynamatic Eddy-Current Equipment for every industrial requirement, including compact drive-package combinations *(illustrated at the right)*.

Dyna-torQ Magnetic-Friction Clutches, Brakes, Clutch-Brakes, and Clutch-Couplings—

provide the accurate trouble-free method of controlling power and motion in modern stop-and-go machines. Eaton Dyna-torQ units utilize a simple operating principle which provides instant response, shockless acceleration and deceleration. Superior construction means long operating life, minimum down-time, low maintenance cost. Outstanding advantages include rapid engagement and disengagement, self adjustment, lower operating temperature through effective cooling, simple accurate control. There is a wide range of sizes and capacities.

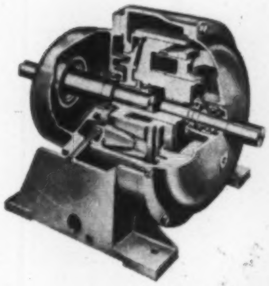
Send for Illustrated Literature Describing
Dynamatic Eddy-Current and Dyna-torQ Equipment



MATERIALS HANDLING

MACHINE TOOLS

Magnetic-Friction Equipment is in Every Major Industry

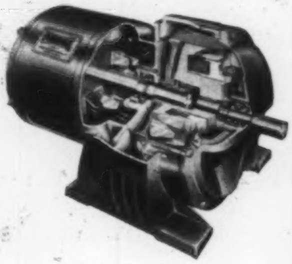


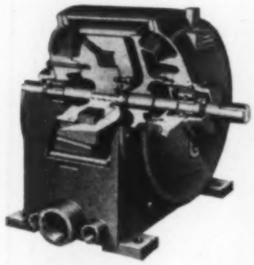
EDDY-CURRENT COUPLINGS

Dynamatic Eddy-Current Couplings transmit torque from driving to driven member without mechanical contact, shock, or friction. Controls provide infinitely adjustable speed from a constant speed source or constant speed from a variable speed source with smooth, controlled acceleration. Liquid-cooled and air-cooled types.

EDDY-CURRENT DRIVES

Dynamatic Eddy-Current Drives consist basically of an integral combination of an AC constant speed induction motor and an eddy-current coupling. Electronic or magnetic amplifier control provides accurate speed control for a wide range of applications. Available in liquid-cooled and air-cooled types.



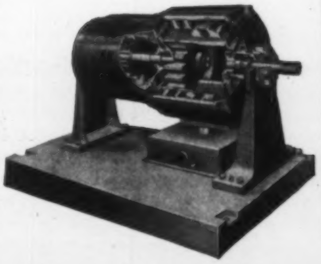


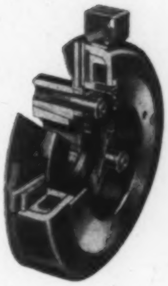
EDDY-CURRENT BRAKES

Dynamatic Eddy-Current Brakes are available in a wide range of torque capacities and operating speeds. Features include smooth, frictionless, shock-free operation with no rotating electrical components or contacts. Liquid-cooled and air-cooled types.

EDDY-CURRENT DYNAMOMETERS

Three types of Dynamatic Eddy-Current Dynamometers are available to meet various testing requirements; absorption dynamometers up to 15,000 HP; motoring or driving dynamometers up to 500 HP; and universal dynamometers to 500 HP and larger. Special purpose dynamometers are also available.



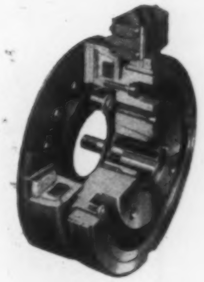


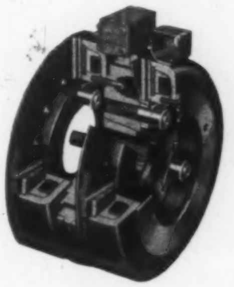
DYNA-TORQ BRAKES

Dyna-torQ Brakes provide controlled deceleration and positive stop with a touch of the control. Rapid, shockless stopping of rotating machine parts reduces interval between operations, and positive holding keeps them motionless between cycles. Compactness and remote control mounting conserve space.

DYNA-TORQ CLUTCHES

With the Dyna-torQ Clutch close control of clutch torque provides soft, cushioned starts, minimizing shock. Driving motors may be brought to operating speed before coupling to the load. Soft clutching permits controlled acceleration.



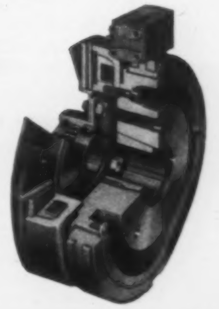


DYNA-TORQ CLUTCH-BRAKES

The Dyna-torQ Clutch-Brake provides closely controlled acceleration and deceleration. It is ideal for applications requiring automatic start-stop operation, eliminating time loss in slow-down between operations, and facilitating accurate automatic cycling.

DYNA-TORQ CLUTCH-COUPLINGS

Compact, simple, Clutch-Coupling parts are installed on shaft ends in the same manner as the halves of a conventional flexible coupling. Designed for clutching of directly-aligned shafts, the Dyna-torQ Clutch-Coupling is easily installed on existing machinery or designed into new equipment.



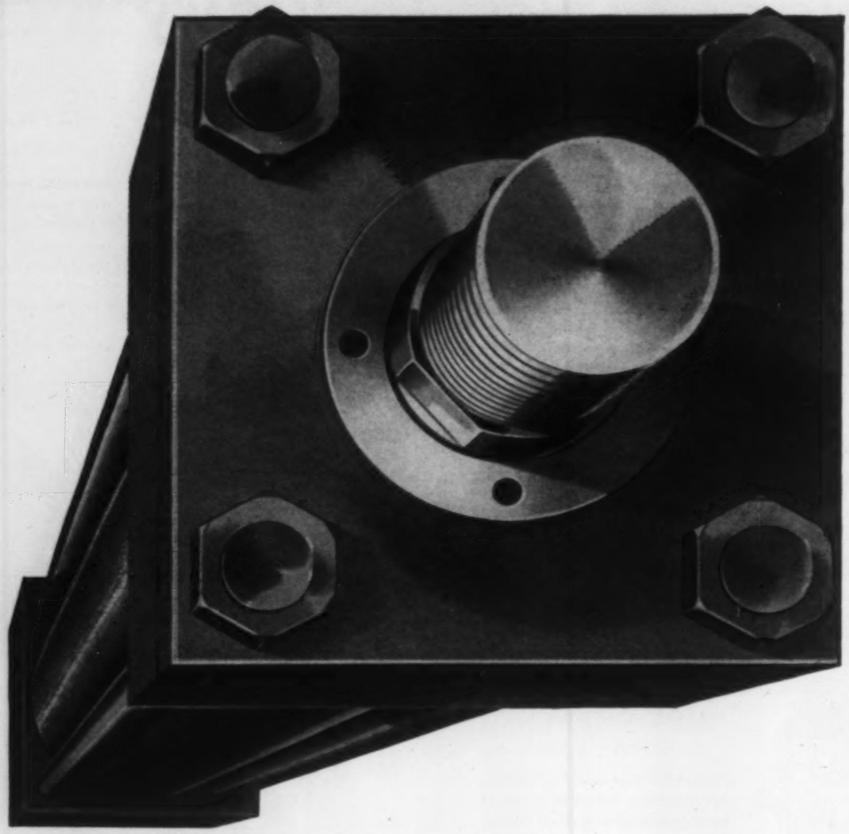
DYNAMATIC DIVISION

EATON MANUFACTURING COMPANY

KENOSHA WISCONSIN

BUSINESS MACHINES

AT YOUR REQUEST...



ANKER-HOLTH

Hydraulic Cylinders now available in Square Head design

Positive Trouble-free Performance

Anker-Holth Division, for 18 years designers and manufacturers of quality air and hydraulic power cylinders, now offers a standard line of all steel, high pressure square head tie rod cylinders. Important new operating features and design achievements assure positive controlled power for a wide range of industrial applications.

Standardized Mountings for Interchangeability

Conservatively rated at 2000 P. S. I. working pressure and 3000 P. S. I. non-shock pressure every cylinder is proof tested at 4500 P. S. I. All mountings are available, standard bores from 1½ to 8 inches. Standardized mountings provide complete interchangeability with most makes of square head cylinders. The Anker-Holth "□" line meets all J. I. C. specifications.

For more information contact your local Anker-Holth representative or Anker-Holth Division, Port Huron, Michigan. YUkon 5-7181

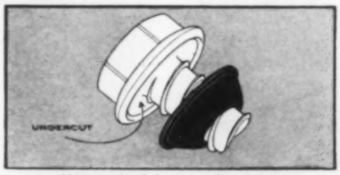
ANKER-HOLTH DIVISION
THE WELLMAN ENGINEERING COMPANY
2726 CONNOR STREET, PORT HURON, MICH., U. S. A.

Circle 472 on Page 19

News about NEOPRENE

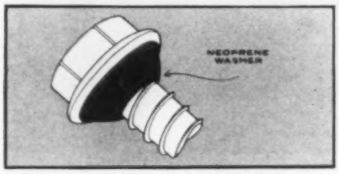
NEOPRENE washers are integral part of leakproof, cushioned fastener

A combination of an undercut head design and a conically shaped neoprene washer gives special advantages to these fasteners.



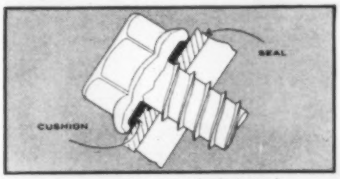
Undercut of fastener head . . .

The washer cushions the head and prevents metal-to-metal contact. Finishes are protected; transmission of vibration noise and squeaks is reduced.



. . . confines and controls flow of conical neoprene washer

As the fastener is secured, the undercut head confines and controls the spread of the resilient neoprene washer, which, in turn, flows into the top threads and seals the fastener hole.



. . . so washer seals the hole and cushions the fastener head.

It's another example of good design made possible with a part made of neoprene—the Du Pont synthetic rubber that is used throughout the automotive industry for resistance to oil, ozone and weather. Just clip the coupon for more information.

Lineman's blankets of HYPALON® take 15,000-volt shock for 147 test hours without damage

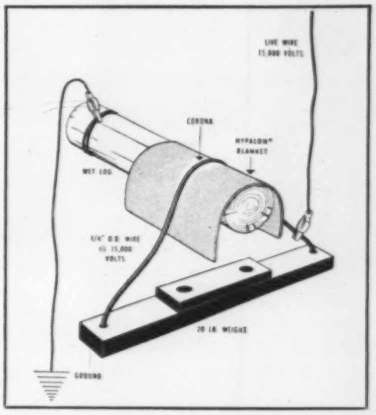
HYPALON retained full insulating value in test that burned through ordinary rubber in 12 minutes

Telephone poles often carry power lines in addition to telephone wires. When a pole needs replacement, telephone linemen usually do the job if power line voltage doesn't exceed 15,000 volts. In jockeying a new pole into position it may brush against the power wires. If the pole is wet it is conductive enough to be dangerous. Wet or not, linemen protect themselves against possible electrocution by wrapping the top of the pole with insulating rubber blankets.

Natural rubber blankets have high insulating value, but are vulnerable to corona cutting and deterioration from sunlight and weather. At the first sign of a cut or burn they must be discarded.

The extraordinary resistance of HYPALON synthetic rubber to ozone, sunlight and other oxidizing agents suggested its use for linemen's blankets to engineers at Bell Telephone Laboratories in Murray Hill, N. J.

Test blanket of HYPALON showed no damage after 15,000-volt test simulating actual service conditions. Test was discontinued after 147 hours.



Bell engineers devised a test closely simulating actual service conditions (see sketch). They soaked a pole stub in water, grounded it, draped a blanket over it, pressed a ¼-in. copper conductor against the blanket and applied 15,000 volts. Resultant arcing produced constant corona and evolved strong ozone. Ordinary rubber blankets failed quickly . . . some in 12 minutes. But a blanket of 100% HYPALON withstood 147 test hours with no corona cuts, ozone cracks or burn-throughs. Longer testing was considered unnecessary.

Performance like this makes HYPALON an excellent choice for parts or products subject to ozone, corona or strong oxidizing conditions. Mail the coupon for details on how this Du Pont synthetic rubber can help you in designing new products and improving old ones.

HYPALON *is a registered trademark of E. I. du Pont de Nemours & Co. (Inc.)*

ELASTOMERS IN ACTION **HYPALON® • NEOPRENE**

DU PONT
REG. U. S. PAT. OFF.
Better Things for Better Living
. . . through Chemistry

☐ I am particularly interested in ______________

☐ Send me a free copy of *The Du Pont Elastomers* (a review of properties of neoprene and HYPALON).

☐ Add my name to the free mailing list of the *Elastomers Notebook* (contains articles based on uses of Du Pont elastomers in industry).

E. I. du Pont de Nemours & Co. (Inc.)
Elastomer Chemicals Dept. MD-2
Wilmington 98, Delaware

Name ______________
Firm ______________
Address ______________
City ______________ State ______

Circle 473 on Page 19

FARNHAM
FARNHAM
precision
belt grinder

...FACTORY EQUIPPED

with ALLEN-BRADLEY *Motor Control*

Have you ever noticed how often you see the familiar A-B trademark of *quality* on motor starters or special motor control panels for production machinery of all types? This outstanding preference for Allen-Bradley control is the result of its *proved* reliability.

Simplicity . . . that's the real key to the reliability of Allen-Bradley solenoid starters and relays. They have only *one* moving part . . . all trouble causing bearings, pivots, and pins are eliminated. This assures *millions* of trouble free operations. And the double break, silver alloy contacts—used in *all* Allen-Bradley controls—are always in perfect operating condition. Contact maintenance is unnecessary . . . even the customary inspection can be limited to once or twice a year . . . where the service is particularly tough.

Insist on Allen-Bradley motor control when buying motor driven plant equipment. There is no better assurance of trouble free operation.

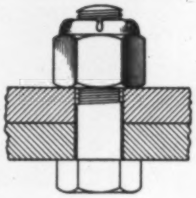
This special control panel was furnished by Allen-Bradley to control the precision belt grinder built by Farnham Mfg. Div. of Wiesner-Rapp Co. All components are standard Allen-Bradley control units listed in the new A-B Handy Catalog. Send for your copy, today.

ALLEN-BRADLEY
MOTOR CONTROL
QUALITY

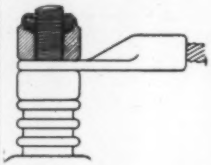
Allen-Bradley Co., 1333 S. First St., Milwaukee 4, Wis.
In Canada—Allen-Bradley Canada Ltd., Galt, Ont.

Ten fastening problems solved by ELASTIC STOP nuts

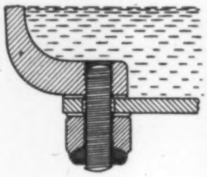
TIGHTENED AGAINST THE WORK



Vibration and impact proof bolted connections in standard applications.

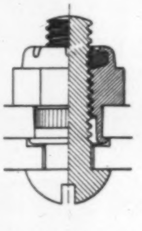


On all electrical terminals subjected to vibration in transit or operation, and for any electrical or electronic assembly where positive contact must be maintained.

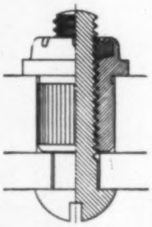


To seal bolt threads where leakage past stud threads must be prevented.

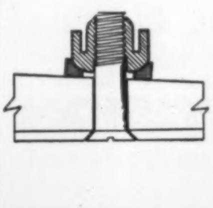
FOR MANY SPECIAL FUNCTIONS



Blind fastening applications where nut is "clinched" into sheet metal . . . becoming self-retaining as well as self-locking.

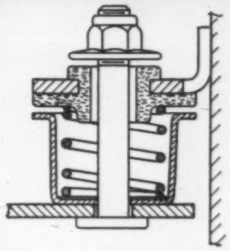


To eliminate drilling and tapping and provide steel thread strength for soft metals, an ESNA spline nut is pressed into a bored hole in casting.

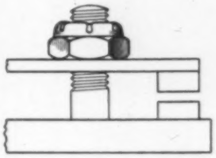


Simplified self-aligning self-locking fastener for bolting two non-parallel surfaces.

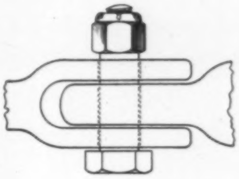
LOCKED ANYWHERE ON THE BOLT



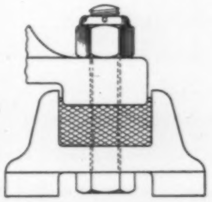
Spring-mounted connections or dynamic balancing, where nut must stay put yet be easily adjusted. (Flanged face eliminates need for extra washers.)



On make and break adjustment studs where accurate contact gaps must be maintained. Note "thin" height design for limited clearance.



For bolted connections requiring predetermined play.



For rubber-insulated and cushion mountings where the nut must not work up or down.

HOW THESE NUTS SOLVE SO MANY FASTENING PROBLEMS, ELIMINATING EXTRA PARTS AND OPERATIONS . . .

The red locking collar of an ELASTIC STOP® nut grips bolt threads with a perfect fit that will not loosen under severe vibration or stress reversals, and seals against liquid seepage. By bringing nut and bolt metal thread flanks into firm contact it eliminates wear producing axial play. The elastic locking action of the insert-type stop nut does not distort or gall bolt threads. It is reusable many times.

Send for the following free information: Elastic Stop nut bulletin; Rollpin® bulletin. Or enclose a drawing of your product for specific self-locking fastener recommendations. Write to Dept. N30-24.

ELASTIC STOP NUT CORPORATION OF AMERICA
2330 VAUXHALL ROAD, UNION, NEW JERSEY

Circle 475 on Page 19

Vickers Magneclutch for Better Torque Transmission . . .

VICKERS®

Magneclutch®

solves difficult tension control problem in slitting machine operation

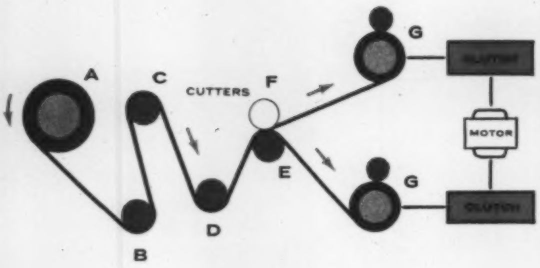
This specialized machine by Gudeman Company of Chelsea, Michigan, slits mil-thick materials such as paper and metal foil for use in capacitors.

As the feed roll is unrolled, slit and rewound, the tension on the material as it passes through the slitting knives and rollers must be accurately controlled, to assure uniform rewinding and to prevent strains, breakage or snarling.

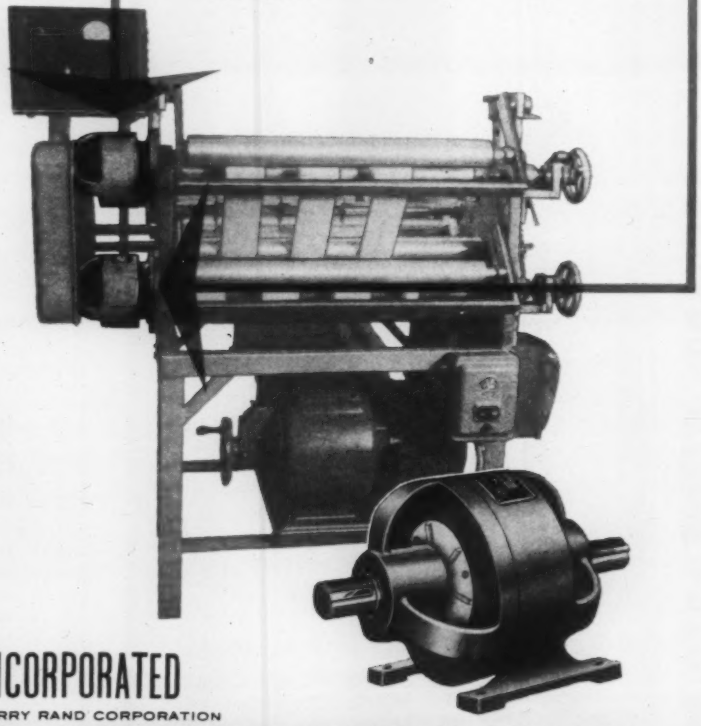
The manufacturer was able to obtain this necessary tension control independent of speed only with the Vickers Magneclutch, after mechanical clutches had failed because of changing characteristics and difficulty in adjusting to changing tension demands.

This, of course, is only one of many practical uses for the Magneclutch, the magnetic particle clutch that provides smooth operation without grab or chatter, torque at zero slip, fast response, and long life because there's no wear on torque transmitting surfaces.

Write for complete information and literature.



Rollers B, C and D pull the material from the unwind roll and establish the speed at which the material flows through the machine. The torque transmitted by the Magneclutch establishes the tension in the material between roller D and roller G. As the diameter of the windup roll increases, the clutch slips automatically, permitting the material to wind up at a constant speed and tension.



ELECTRIC PRODUCTS VICKERS DIVISION

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
ELECTRIC PRODUCTS DIVISION
1881 LOCUST STREET • SAINT LOUIS 3, MISSOURI

Circle 476 on Page 19

ORIGINAL CAMERA FILM
FL ASSY-ELECTRICAL CHASSIS
1W741
225
C1/C1
RECORDAK CORPORATION
(Subsidiary of Eastman Kodak Company)
Reduces Costs
Improves Quality
Provides Faster Service
RECORDAK PRECISION
DRAWING SYSTEM
SAMPLE

Decks of cards replace acres of files

New Recordak Engineering drawing system simplifies filing, reference, printmaking and print distribution . . . seems destined to change drafting-room procedures the world over.

An exclusive Recordak development. New microfilming techniques and quality-control methods perfected by Recordak give results never before achieved in 35mm microfilming. These pictures are of such outstanding quality they increase the scope of Filmsort aperture cards . . . supplant use of bulky blueprints and drawings in many drafting-room routines.

Just how do these new Recordak pictures differ from others?

In one important way—now, all types of drawings, prints, specification sheets—negatives or positives, old or new, clean or dirty—can be reproduced uniformly on low-cost 35mm Recordak microfilm *without loss of detail!* Important, too—enlargements made from them are as readable as the originals.

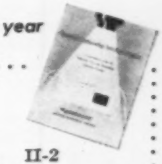
The next step in the Recordak System—mounting these superb Recordak reproductions on individual cards puts complete drawing files at fingertips . . . saves engineering time, steps up efficiency. Large organizations can realize further economies by correlating their use with existing mechanized filing, duplicating and enlarging systems.

See how new Recordak System helps: Files cut 95% • Any picture can be checked immediately in Film Reader • Microfilm cards can always be filed in any numbered sequence • Paper prints or duplicates made rapidly by photographic or electrostatic method • Branches, subcontractors supplied at lowest cost.

FREE BOOKLET tells how this System can work for you. Includes sample Recordak Microfilm frame mounted on Filmsort aperture card. Mail coupon today.

"Recordak" is a trademark

RECORDAK
(Subsidiary of Eastman Kodak Company)
originator of modern microfilming—*now in its 30th year*



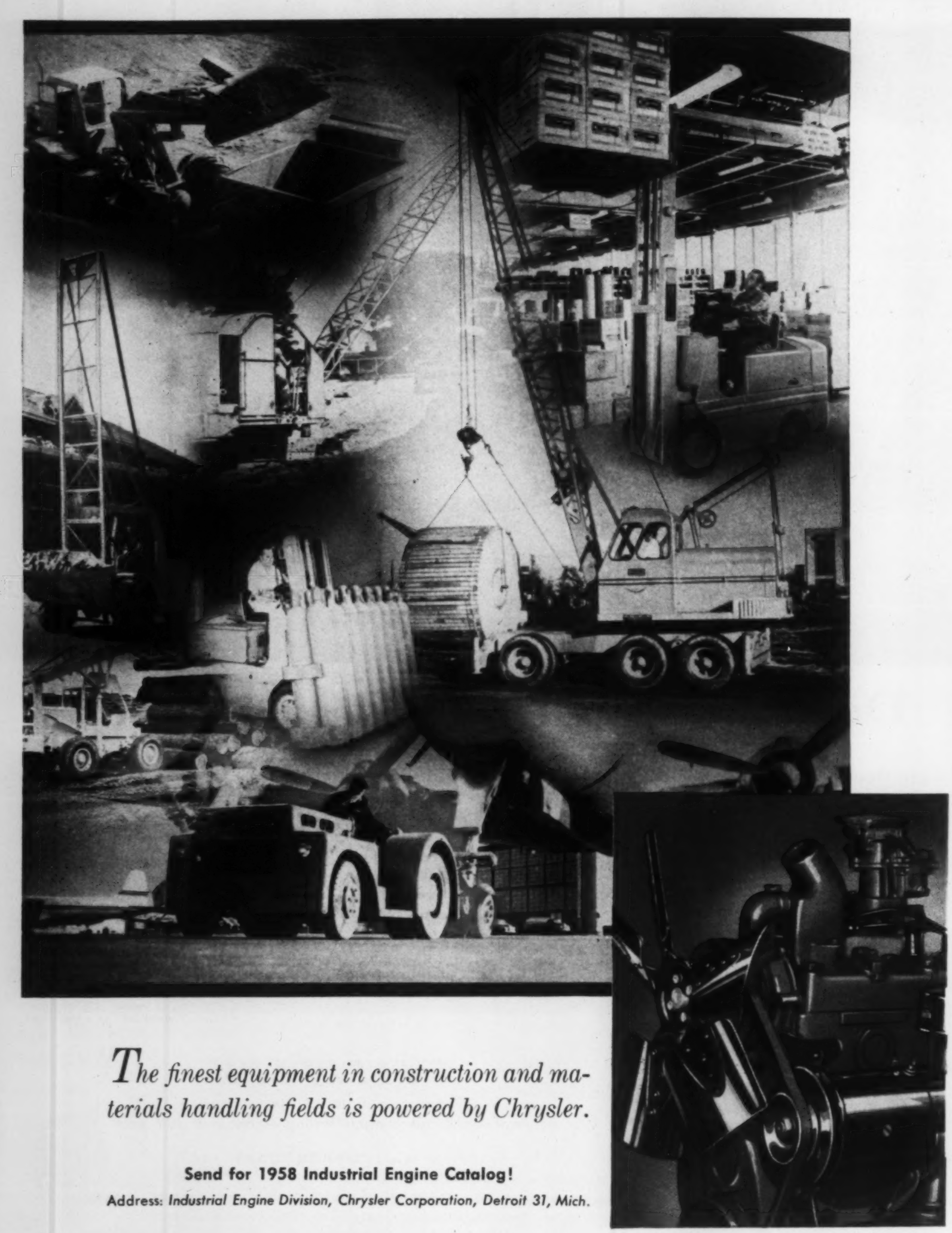
MAIL COUPON TODAY

RECORDAK CORPORATION
415 Madison Avenue, New York 17, New York

Gentlemen: Send free booklet describing new Recordak Engineering Drawing System. No obligation whatsoever. **II-2**

Name__________
Company__________ Title__________
Address__________
City__________ State__________

Circle 477 on Page 19



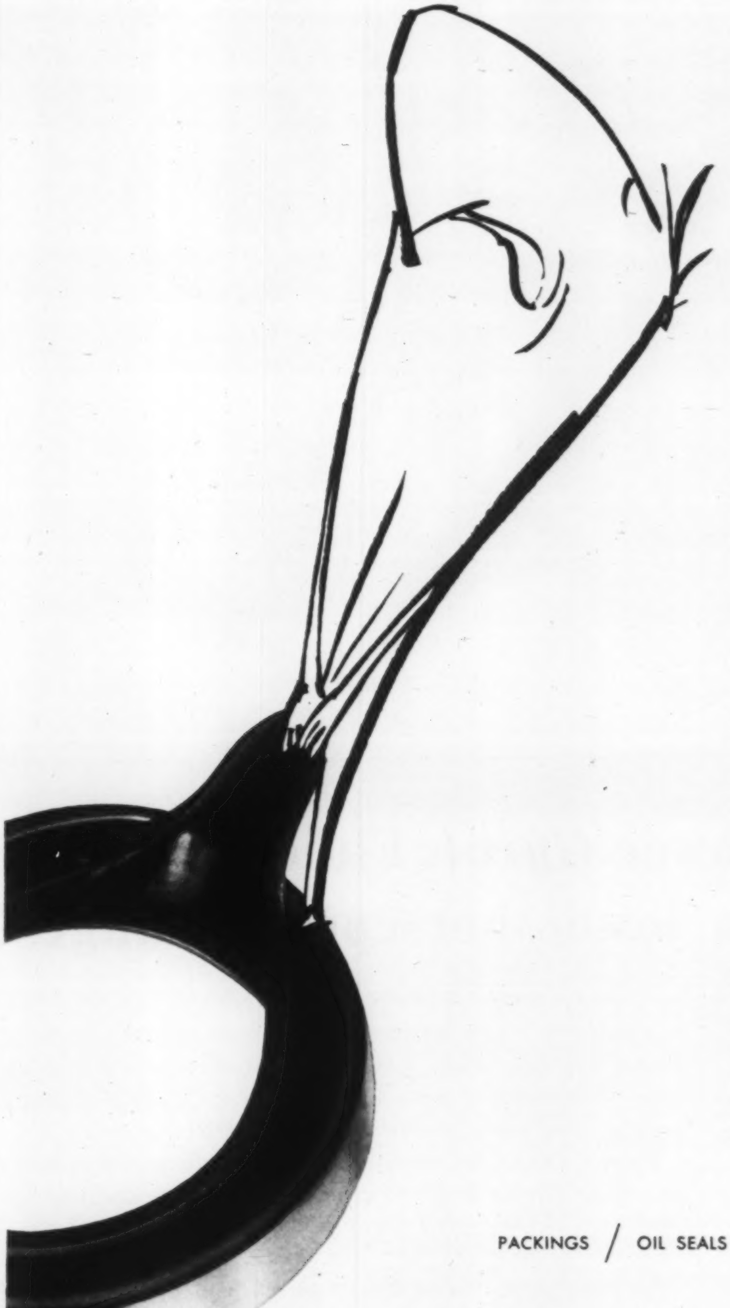
The finest equipment in construction and materials handling fields is powered by Chrysler.

Send for 1958 Industrial Engine Catalog!

Address: *Industrial Engine Division, Chrysler Corporation, Detroit 31, Mich.*

Chrysler INDUSTRIAL ENGINES

INDUSTRIAL ENGINE DIVISION • CHRYSLER CORPORATION



ABSOLUTE ADHESION

BONDED BY IPC

IPC's bonding technique can mean money saved and a problem solved for you.

IPC has developed a special bonding process which provides *absolute adhesion* between rubber and metal in their bonded case seals and bonded washer seals. In tests much more severe than any normal application, the IPC "bond" would not break down.

This special process enables us to manufacture a finer oil seal with simplicity of design which means lower cost and improved performance.

IPC's custom bonding process is your protection against seal failure. For the answer to your particular sealing problem, contact IPC. Our "custom" approach to both design *and* manufacture is your assurance of greater savings and dependability.

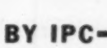
PACKINGS / OIL SEALS / PRECISION MOLDING

IPC

BONDED BY IPC

1. Bonded Washer Seal Double Lip Wiper

3. Bonded Washer Seal Straight Lip


5. Bonded Washer Seal Straight Lip With Garter Spring

7. Bonded Case Seal Straight Lip

9. Bonded Case Seal Straight Lip With Garter Spring

11. Bonded Case Seal Straight Lip Thin Rind Type

13. Rubber Covered Bonded Case Seal Straight Lip

15. Rubber Covered Bonded Case Seal Straight Lip With Garter Spring

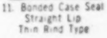
2. Bonded Case Seal Double Lip Wiper

4. Bonded Washer Seal Limited Contact Lip

6. Bonded Washer Seal Limited Contact Lip With Garter Spring

8. Bonded Case Seal Limited Contact Lip

10. Bonded Case Seal Limited Contact Lip With Garter Spring


12. Bonded Case Seal Limited Contact Lip Thin Rind Type

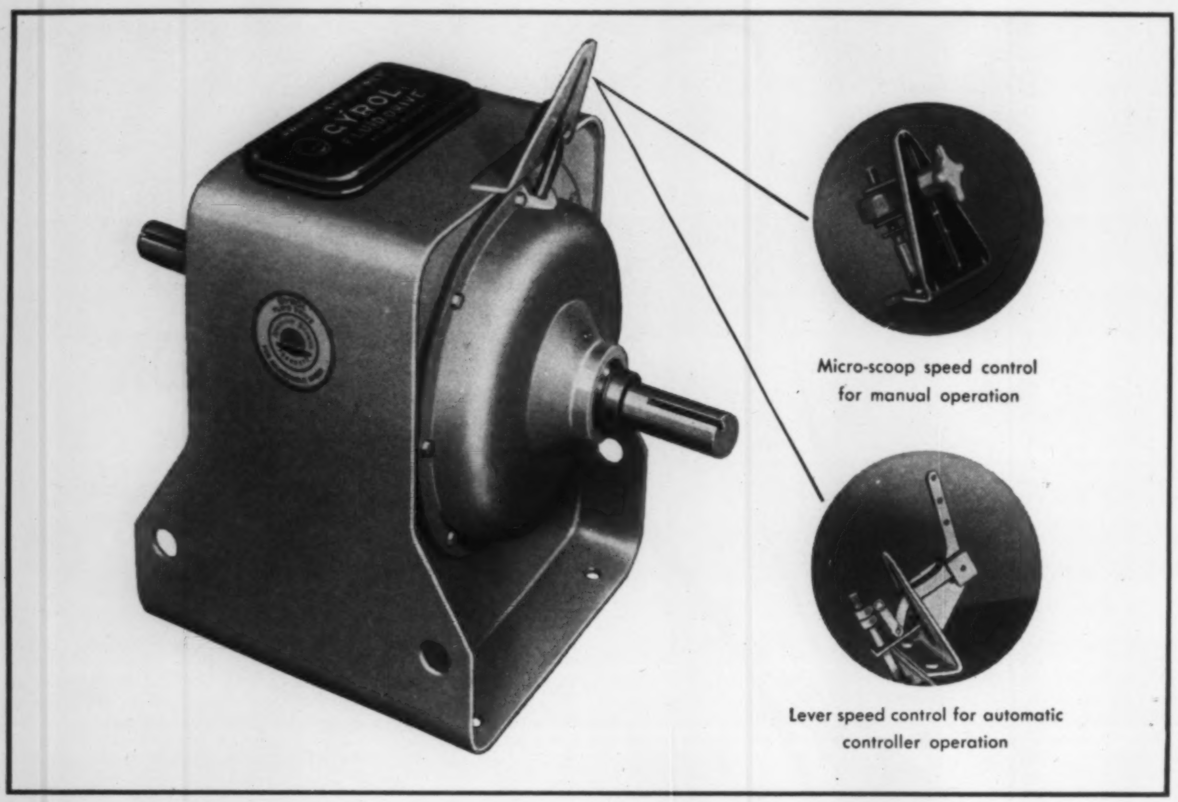
14. Rubber Covered Bonded Case Seal Limited Contact Lip

16. Rubber Covered Bonded Case Seal Limited Contact Lip With Garter Spring

INTERNATIONAL PACKINGS CORPORATION
Bristol, New Hampshire

P1

Circle 479 on Page 19



Micro-scoop speed control for manual operation

Lever speed control for automatic controller operation

American Blower *Gýrol*® Fluid Drives now available in lower horsepower ranges!

Type VS, Class 2 Gýrol Fluid Drives for 1- to 25-hp applications. Also available with flange-mounted motor, as shown.

Adaptable to either automatic or manual control, American Blower Type VS, Class 2 Gýrol Fluid Drives come in a complete range of new smaller sizes—1 hp to 25 hp, speeds to 3600 rpm—to satisfy your every power-transmission need!

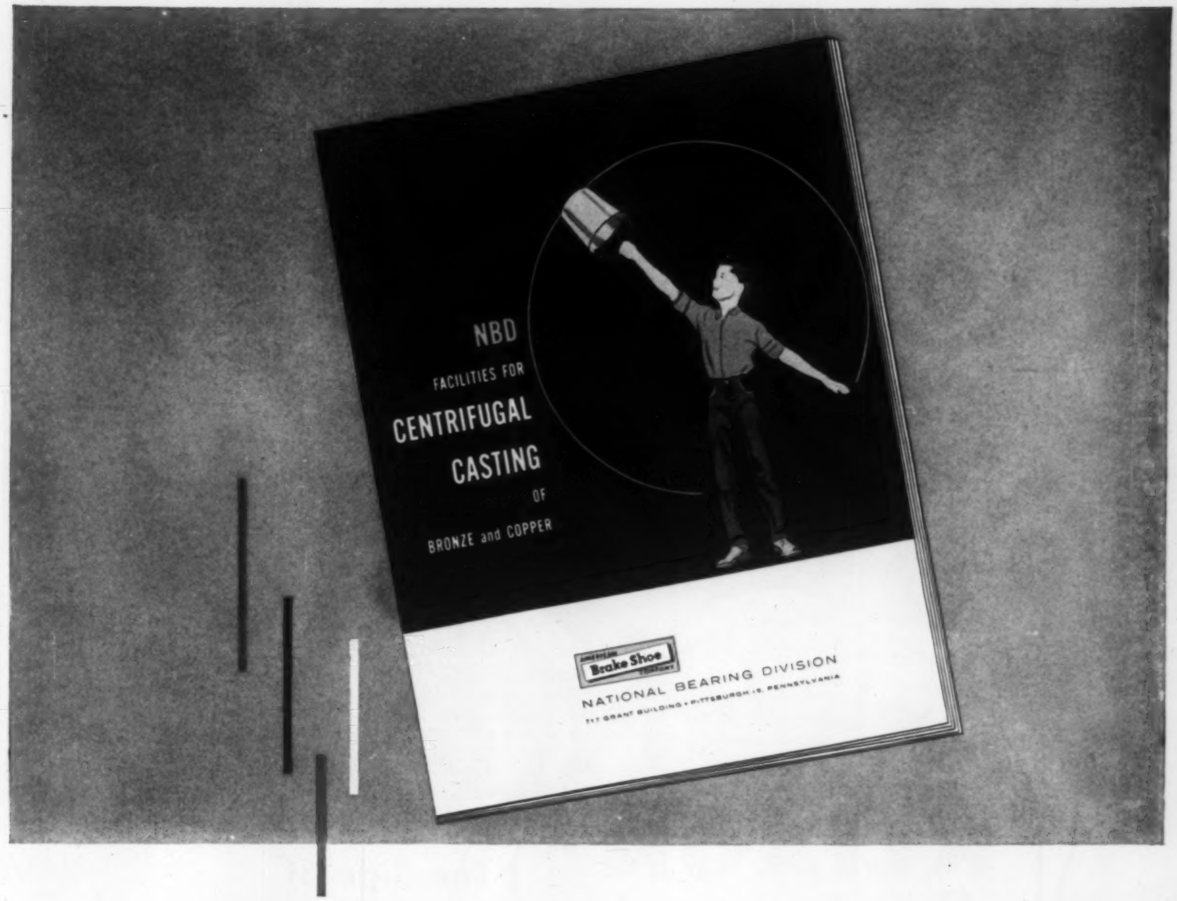
These compact, self-contained units offer an answer to many industrial-drive problems because of their important benefits: adjustable, stepless speed control; full reversibility; 5 to 1 speed range; no-load starting; protection against shock; quiet operation.

For full information on the complete line of Type VS, Class 2 Gýrol Fluid Drives, 1-800 hp—or other designs to 12,000 hp—contact our nearest branch office. Or write: American Blower Division of American-Standard, Detroit 32, Michigan. In Canada: Canadian Sirocco products, Windsor, Ontario.

AMERICAN BLOWER

Division of **American-Standard**

American-Standard Products



NBD
FACILITIES FOR
CENTRIFUGAL
CASTING
OF
BRONZE and COPPER

AMERICAN Brake Shoe COMPANY
NATIONAL BEARING DIVISION
717 GRANT BUILDING • PITTSBURGH 19, PENNSYLVANIA

HOW **NBD** CENTRIFUGAL CASTING CAN CUT COSTS OF BRONZE PARTS

Engineers know that centrifugal castings have a man-sized strength and soundness hard to match.

This means that in many cases you can design a big part smaller . . . a heavy part lighter . . . and you still get the casting strength you want.

Cost saving can be substantial.

Find out now where you can use NBD centrifugal bronze castings and save. We'll help you with the engineering.

Mail this coupon for the new NBD Facilities for Centrifugal Casting book. It'll show you the alloys, weights and sizes NBD is equipped to centrifugally cast and machine.

AMERICAN **Brake Shoe** COMPANY

NATIONAL BEARING DIVISION
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NBD Facilities for Centrifugal Casting book.

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THIS IS A
KLIXON
Protected
MOTOR

The Sign of Dependable Protection for single and 3-phase motors

Built-in KLIXON automatic and manual reset protectors for 3-phase motors prevent overheating of windings caused by:

- Prolonged overloads
- Single phasing
- Stalling
- Failure to start
- Lack of ventilation
- Increase in ambient temperature
- Plugging or reversing duty
- Unbalanced voltage

Today more and more 3-phase motor manufacturers are furnishing dependable protection against hidden damage to motor insulation which results from overheating and which usually leads to burnout. They do this by engineering KLIXON Motor Protectors into their motors.

The advantage to you is that you get maximum work output and minimum down time from your 3-phase motors. And, you can get this protection built into your 3-phase motors from fractional up through 7½ HP (600V) sizes.

Check with your motor supplier on how to get KLIXON protected motors when you place your next order — the additional cost is more than offset by the savings. We'll be glad to send you literature on request, too — no obligation.

METALS & CONTROLS CORPORATION
Spencer Thermostat Division 3202 Forest Street, Attleboro, Mass.
KLIXON ®

Circle 482 on Page 19

protecting products the Caplug way
can save you hundreds $$ . . . for pennies spent

quick to put on…and quick to take off…fit tremendous
variety of tubing, threaded fittings and machined parts

Caplugs

take your pick from this big closure family
…10 standardized styles…over 500 sizes in stock

molded of flexible Polyethylene
. . . won't chip, break, shred or collapse

get a free handful of Caplugs like this
in exchange for the coupon below

tough enough to take abuse
…yet, most kind to threads and polished surfaces

CAPLUGS DIVISION, PROTECTIVE CLOSURES CO., INC.
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Mail a free assortment of Caplugs, literature and prices to us, without obligation.

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FIRM ____________________________________

ADDRESS __________________________________

CITY ______________ ZONE ______ STATE ________

Circle 483 on Page 19

Multiple Operations
can often be reduced to **Two**
with **Madison-Kipp**
zinc and aluminum die castings

Tool designers, frequently, influence the selection of die castings to reduce tooling costs and to reduce the number of machine and assembly operations required.

Cooling fins, for instance, can be stamped and formed and assembled to a housing with multiple operations. Seasoned die designers and expert tool makers at Madison-Kipp can usually make a more efficient, stronger and lighter part in one die casting operation plus a fast trimming job.

Possibly similar savings can be applied to your parts. We will be glad to try to assist in analyzing your problems.

Please clip this ad as a reminder to contact us when you have die casting requirements.

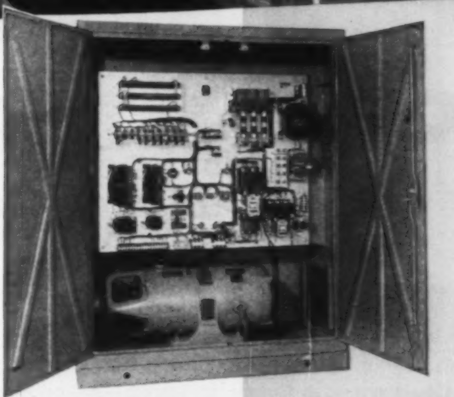
kipp

MADISON-KIPP CORPORATION
210 WAUBESA STREET • MADISON 10, WIS., U.S.A.

Skilled in Die Casting Mechanics • Experienced in Lubrication Engineering • Originators of Really High Speed Air Tools

Which Type ADJUSTABLE SPEED DRIVE CONTROL Do You Need? SQUARE D BUILDS BOTH!

Typical application of Adjustable Voltage
Drive to large metal spinning lathe
in operation at Phoenix Products Company,
Milwaukee



ADJUSTABLE VOLTAGE CONTROL FOR M-G SETS...Through 400 HP

Simplified Circuits with rugged heavy-duty control components.

Easy Maintenance because standard magnetic starters, relays and timers are used in combination with static regulators.

3 Types Available • (*1*) magnetic amplifier exciters (*2*) dry disc exciters (*3*) rotating exciters.

Easy to Adjust because centralized "tune-up" elements are accessible and readily identified.

FULLY ELECTRONIC with SIMPLIFIED FAIL-SAFE CIRCUITS THROUGHOUT

Simplified Circuits use less tubes. Fail-safe circuits prevent motor runaways.

Easy Maintenance because sub-panels can be quickly removed and replaced. "Brain" panel senses varying conditions.

Easy to Adjust with only a few, very accessible potentiometers.

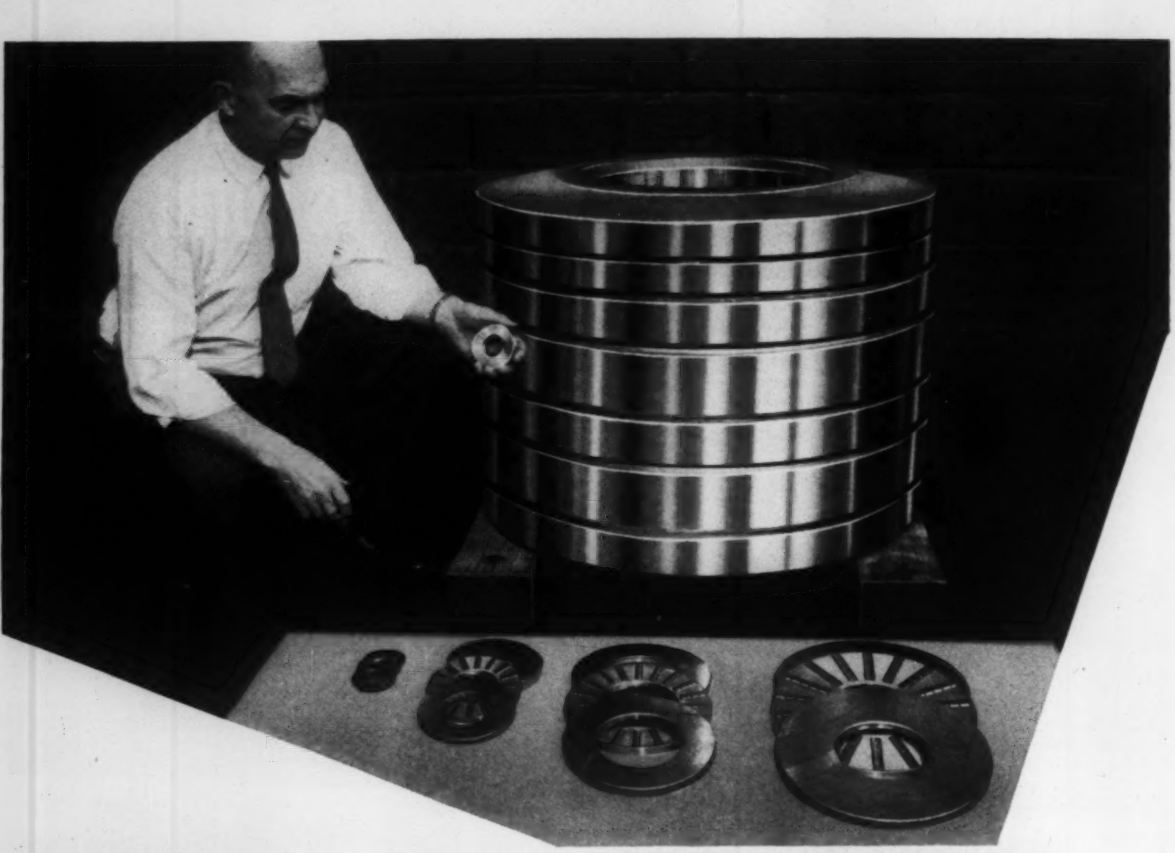
Both types are available in two kinds of construction—standard package and custom-built.

Write for descriptive literature. Address Square D Company,
4041 North Richards St., Milwaukee 12, Wis.

EC&M HEAVY INDUSTRY ELECTRICAL EQUIPMENT...NOW A PART OF THE SQUARE D LINE

SQUARE D COMPANY

Circle 485 on Page 19



ROLLWAY THRUST BEARINGS...

→ $\int_{2''}^{36''}$ *Design + precision + quality that do the job in the* *one best way...*

Size in Rollway Thrust Bearings—big or little—is a mere matter of operating "geometry" and of the machinery to produce it. But design, precision and quality are dimensionless quantities that vary widely according to loads, speeds, temperatures . . . yet in the end sum up to a single constant: *"To do the job required in the one best way."*

Of course, we're proud of this 2¼ ton bearing with its thrust load capacity of 4,630,000 lb., its diameter of almost 3'-0" and its 3 roll assemblies with 6 precision thrust plates matched to equalize load and deflections for each stage. But we're equally proud of the little 2 incher in Design Engineer Grigson's hand. Despite the great difference in size, each has been carefully worked out *"to do the job required in the one best way."*

Whether you want a bearing for an oil rig, an extruder, a pulp mill jordan, a crane hook, a heavy duty lathe and countless other uses, Rollway has one that will do the job "in the one best way."

ROLLWAY®
BEARINGS
COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

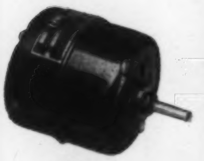
5 Standard Types:

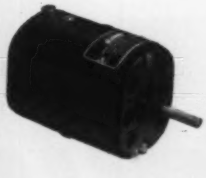
- Single aligning
- Double aligning
- Tandem
- Single acting
- Double acting
- Special-purpose types to your order

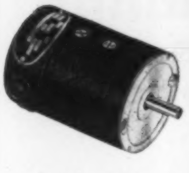
Our engineers will gladly consult with you regarding the standard or special-purpose types you need.

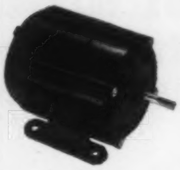
ENGINEERING OFFICES: Syracuse • Boston • Chicago • Detroit • Toronto • Pittsburgh • Cleveland • Milwaukee • Seattle • Houston • Philadelphia • Los Angeles • San Francisco

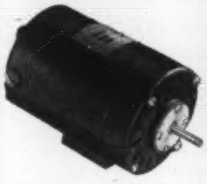
Circle 486 on Page 19


MODEL 11A


MODEL IMPERIAL


MODEL 100


MODEL 512


MODEL 700

MODEL 1100

MORE THAN 50,000 *DIFFERENT SPECS* HAVE BEEN FILLED BY THESE 6 HOWARD UNIVERSAL AND D.C. FRACTIONAL H.P. MOTORS

These 6 Howard motors account for over 50,000 specifications, both military and commercial. One reason for this wide use is Howard's ability to produce variations *exactly* suited to specific needs.

Howard motors have such field-proven engineering features as automatic slot cell insertion, which practically eliminates "grounds;" Zanderoll processed double dipped and double baked armatures providing deep, uniform varnish penetration for high bond strength and rock-hard coils minimizing "shorts and opens;" improved brushholder construction for accurate alignment and longer life; 2-stage, 3-plane dynamic balancing; and automatic winding for tough compact coils, giving uniform performance.

If you are currently using universal and D.C. motors from 1/200th to ½ H.P., check with Howard today.

GEAR REDUCTION UNITS

Model	Ratio	
	min.	max.
11A	3:1	2700:1
Imperial	3:1	2700:1
100	3:1	2700:1
512	3:1	2700:1
700	21.5:1	2600:1
1100	3:1	2700:1

ELECTRICAL SPECIFICATIONS

	MODEL 11A		MODEL IMPERIAL		MODEL 100		MODEL 1100		MODEL 512		MODEL 700	
	SERIES MOTOR	SHUNT MOTOR	SERIES MOTOR	SHUNT MOTOR	SERIES MOTOR	SHUNT MOTOR	SERIES MOTOR	SHUNT MOTOR	SERIES MOTOR	SHUNT MOTOR	SERIES MOTOR	SHUNT MOTOR
NO LOAD SPEED (RPM)	15M	3.5-10M	18M	2-10M			15M	3.5-10M	15M	2-9M	18M	9M
FULL LOAD SPEED (RPM)	5-10M	3-8M	5-10M	3.5-8M	5-10M	1.8-6M	5-10M	3-8M	5-10M	1.8-6M	5-10M	1.8-6M
MAX. H.P. CONT. @ MAX. R.P.M.	1/75 No Fan	1/75 No Fan	1/15	1/20	1/50	1/50	1/50	1/50	1/10	1/12	1/4	1/8
MAX. H.P. INTER. @ MAX. R.P.M.	1/20	1/20	1/8	1/10	1/13	1/13	1/15	1/15	1/5	1/6	1/2	1/4
FULL LOAD AMPS. CONT. @ 115V	.4	.4	1.1	1.1	.35	1.6 at 24V	.40	.45	1.5	1.5	3.2	1.7
FULL LOAD AMPS. INTER @ 115V	.75	.75	2.0	2.0	1.0	5 at 24V	.75	.80	3.0	3.0	5.6	3.0
% EFF. AT FULL LOAD CONT.	30	30	35	30	35	35	40	30	50	45	60	50
% EFF. AT FULL LOAD INTER.	35	35	30	45	45	45	45	45	60	55	65	55
VOLTAGE	12-115	6-120	24-115	6-120	12-120	6-32	12-230	6-120	24-230	12-230	24-115	6-230
ROTATION	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.	CW, CCW, REV.

Maximum H.P. ratings are shown. Variations are available for less power to meet application requirements.

Other Howard motors: UNIVERSAL & D.C. 1/200 to 1/2 h.p. • SHADED POLE 1/2000 to 1/8 h.p.
INDUCTION 1/1400 to 1/8 h.p. • SERVO MOTORS • GEAR MOTORS • BLOWERS

HOWARD

HOWARD INDUSTRIES, INC., 1735 STATE ST., RACINE, WIS., TELETYPE: RAC 344

Sales Offices
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942 S. La Brea Ave., Los Angeles 36
Room 4822, Empire State Bldg., New York 1
300 Broadway, Camden, New Jersey

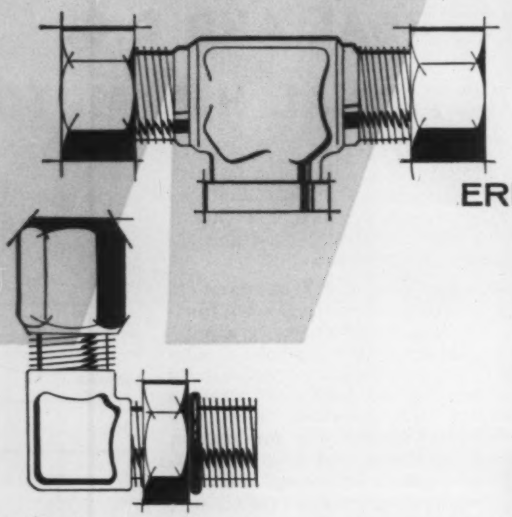
Buy Defense Bonds

DIVISIONS: EMC ELECTRIC MOTOR CORPORATION · CYCLOHM MOTOR CORPORATION · RACINE ELECTRIC PRODUCTS

Circle 487 on Page 19

WEATHERHEAD

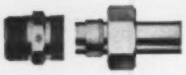
steel tube fittings for high-pressure applications



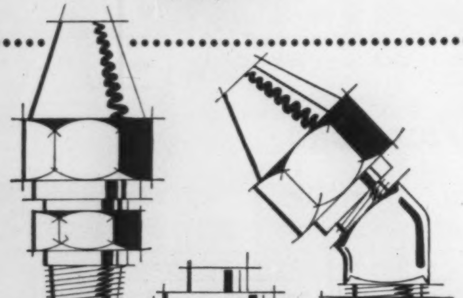
ERMETO®

NO FLARING • NO THREADING
NO WELDING • NO SOLDERING

Steel and stainless steel Ermeto fittings in sizes and types to meet any high-pressure need. Also straight-thread Ermeto fittings to meet new S.A.E. boss specifications.



NOTE—All 7000 Series straight-thread Ermeto fittings and components have corrosion-resistant "Weathercote" finish.



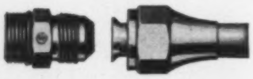
FLARE-TWIN*

S.A.E. 37° Flare-Twin (J.I.C.) fittings are available with Dryseal-thread or with new straight-thread in popular styles and sizes for S.A.E. "O" ring boss design. Available with cadmium-plate or new corrosion-resistant Weathercote finish.

**Trade name for the new Weatherhead 37° flared fitting.*

3-PIECE TYPE

2-PIECE TYPE



NFPA NATIONAL FLUID POWER ASSOCIATION

WEATHERHEAD
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MACHINE DESIGN
February 20, 1958

The Lone Wolf

LIKE some of his fellow engineers, Joe was the victim of a defense cutback. After years of hearing about the shortage of engineers, he suddenly found himself part of an apparent surplus.

An attractive job opening, for which he was well qualified, came to his attention. In the course of interview he made a particular point of inquiring about company policy toward the professional status of engineers. In turn he was asked about his own professional activities—to what societies he belonged and the extent of his participation. The fact that Joe was not a member—active or inactive—of any professional engineering society placed him at some disadvantage in the ensuing discussion.

Society membership does not in itself create a professional man, any more than does education or experience. But it does symbolize an attitude.

The nonjoiner's attitude may be compounded of procrastination and a "what's in it for me?" viewpoint. Thereby he might appear to class himself with the followers rather than the leaders.

We'll be the first to agree that existing professional societies fall short of perfection. But when membership in a society totals less than 25 per cent of eligible engineers in the branch it serves —a not uncommon ratio—whose fault is it if the society appears to be dominated by a nonrepresentative group?

The engineer who is registered and belongs to one or more professional societies has stood up to be counted as a professional man. How professional he actually is depends, of course, on his participation in furthering the aims of the profession. His society simply provides the machinery for such participation, in addition to opportunities to widen his horizons and his acquaintanceship.

Since his interview Joe has been much less vocal on the subject of professional recognition. He realizes that, as a lone wolf, he should not expect to hitch a free ride to professional status on the shoulders of others.

Colin Carmichael
EDITOR

How To Combine

Research + Engineering + Markets

. . . to gain profitable new products

By PHILIP R. MARVIN
Manager, Research and Development Div.
American Management Association, New York, N. Y.

New-product development programs require more than just research and engineering. Without apparent opportunities for profitable business, new products are never marketed. Investigation and evaluation of these opportunities are therefore all-important phases of new-product development programs.

The program must be studied, directed, and evaluated from a commercial standpoint. Whether handled by one man or a division, the commercial - development function steers the entire program.

Optimum results are achieved when the steering is done by a group of diversified individuals, with both technical and economic backgrounds represented. This group, the overseer in a well-integrated program, is of vital interest to engineers who are part of, or in charge of, the engineering phases of product development. Purpose, duties, and organization of a typical commercial-development department are outlined here.

TO ACHIEVE growth objectives, companies must set up organization structures that are adapted to the job of detecting business opportunities. These opportunities usually result from technological advances, design developments, or changing business patterns.

Technological advances are constantly creating new business opportunities as research adds to our knowledge of phenomena, materials, and the arts. When the company's own research programs contribute new knowledge and understanding, proprietary interests can be acquired.

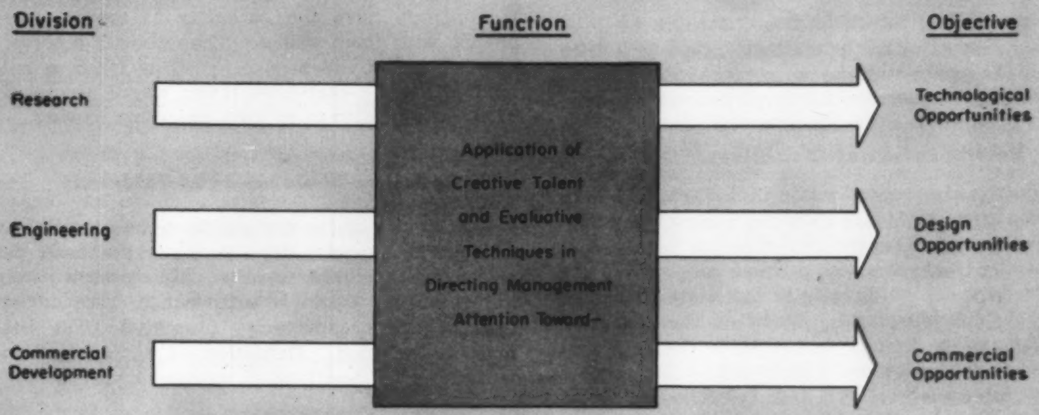
Design developments result in business opportunities which should not be overlooked. Such developments reflect both application of new knowledge from research, and new ways of using older, established concepts, principles, and materials.

Changing business patterns provide a third major source of business opportunities. Top management frequently holds itself responsible for maintaining a look-out for these opportunities. Demands on management's time may make this the most vulnerable point in the corporation. Therefore, some corporations insure against this risk by organizing a commercial-development group to study constantly changing business patterns.

Corporations that have research, engineering, and commercial-development groups are ideally structured. They are making use of creative and analytical talent in every area where new business opportunities are likely to be detected.

▶ Role of the Commercial-Development Group

Development of commercial opportunities is the primary responsibility of the commercial-develop-


Division
Function
Objective
Research
Engineering
Commercial Development
Application of Creative Talent and Evaluative Techniques in Directing Management Attention Toward—
Technological Opportunities
Design Opportunities
Commercial Opportunities

Comparative functions of research, engineering, and commercial-development divisions of the product-development organization

ment group. Because of a close relationship to the business scene, this group occupies a pivotal position in development programs. The work of this group encompasses the following activities:

1. Search for new-product ideas
2. Development of industry growth trends (and decline trends, too)
3. Business-conditions analysis
4. Consumer preference and demand studies
5. Appraisals of product performance
6. Analysis of product lines and product "mix"
7. Definition of potentially profitable product concepts
8. Recommendations on the relative commercial feasibility of proposed research and engineering programs and new-product concepts
9. Co-ordination of business-development programs
10. Surveys of various types
11. Consultation services for other divisions
12. Development of corporate-acquisition programs
13. Periodic re-evaluation of programs and projections
14. Development of business-development programs

These are broad responsibilities, but each is vitally important in planning for future growth and in achieving growth objectives.

Product and Market-Oriented Evaluation: At one extreme, the company has an idea and wants to know its worth. At the opposite extreme, the company wants to know what opportunities exist for new products that would fill an unsatisfied need.

In the first case, where the company has an idea, the evaluation process is product-oriented. In the second case, evaluation is market-oriented.

Product-oriented evaluations generally present the most perplexing problems because of pressure for prompt and affirmative action. Those who present new ideas generally consider themselves greatly misused if they receive anything short of overwhelming and enthusiastic endorsement.

Market-oriented evaluations may be even more important to the corporation. Since no personal interests are involved, pressure is rarely exerted. Regardless of the fact that evaluation of opportunities extends to the two extremes represented by product and market-oriented evaluation programs, both must fit into over-all corporate objectives—they must be company-oriented as well.

Orienting Objectives: The commercial-development group can be of substantial assistance in establishing properly oriented programs. When engineers and research scientists know the objectives management has set, they know what is expected and can work toward these goals. Too often, management's objectives are not known because management itself has not formulated any objectives.

Executives may fall into the habit of citing objectives to excuse positive or negative positions. It is easy to turn down a proposal because it is not in line with objectives. At the same time, executives who justify their actions by ready reference to objectives are often unable to explain the significance of these objectives.

Incorporation of new products into the corporation's product portfolio calls for:

1. Determination of objectives.
2. Detection of ideas and markets.
3. Definition of commercial potentials.

4. Decision making.
5. Direction of development programs.

Responsibility for these five functions must be fixed. For effective operations, these activities should be centralized in a group given full responsibility for commercial-development programs.

1. Determination of Objectives

Objectives represent goals to be achieved in a specified time period and are the basis of planning. Some executives regard objectives as highly confidential. Goals serve no purpose unless they are known to everyone directly or indirectly concerned with their achievement. Much of the confusion in planning is directly traceable to the fact that goals are not known and understood.

Setting up objectives and re-evaluating them take time and skill. As new opportunities arise, old objectives should be appraised and, when necessary, restated in accordance with changed conditions.

2. Detection of Ideas and Markets

The commercial development group develops inside and outside sources to draw upon in developing ideas and market information—enlarging total effectiveness of the corporation's efforts.

The group is then in a position to meet with research scientists, engineers, and others to assist them in understanding the commercial significance of programs. Information about related developments having a direct bearing on specific programs is supplied and market requirements interpreted.

Given full responsibility for the development of new business, the commercial-development group acts independently in using outside research, engineering, and marketing services where necessary. This is desirable for a number of reasons. Research, engineering, and marketing may not be staffed or have time to take on additional assignments.

For the long-run best interests of the company, exploratory programs should not be blocked by such factors—nor should the commercial-development group have the authority to compel compliance with their wishes. They should, however, be free to act independently. This freedom will tend to exert a corrective effect where necessary. The real objective is to keep programs moving.

3. Definition of Commercial Potentials

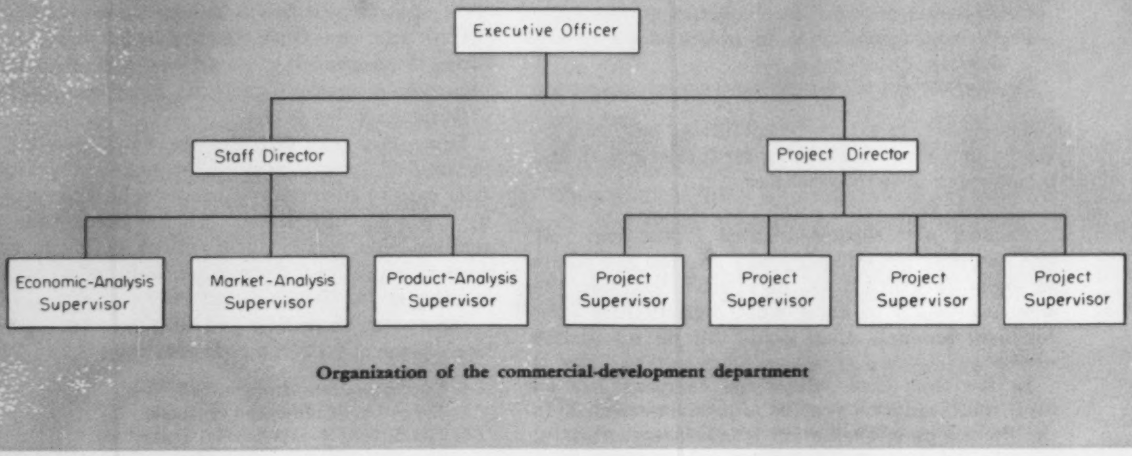
A summary of the commercial potential of ideas and market opportunities provides the basis for measuring their relative value. Management rarely has resources available sufficient to take advantage of every opportunity presented. The best must be selected. Definition of commercial potentials is a "positioning" process involving four steps:

1. Clarification of ideas and concepts
2. Management acceptability
3. Patentability
4. Technical-economic evaluation

The primary responsibility of the commercial-development division is the development of commercial opportunities, with full responsibility for commercial-development programs. Ideas and concepts are examined to measure their commercial potential, and formal presentations are made to management.

To do this most effectively, members of the commercial-development group should have an intimate acquaintance with top-management thinking. The group should be so thoroughly acquainted with management thinking that it can recognize management's need for additional background data and initiate studies without waiting for management to specifically request them. While management in certain instances may request special studies, it should be a recognized responsibility of the commercial-development division to initiate studies and surveys as quickly as the need is noted.

In this respect, the commercial-development di-



Organization of the commercial-development department vision functions as a management-services group. This relationship to top management is vitally essential to successful performance of the functions of the division. At all times, the commercial-development division must be thoroughly informed and coversant with business activities within and outside the corporation. Its own work should reflect leadership in business thinking.

As research reveals technological opportunities and engineering suggests design opportunities, commercial development should point to commercial opportunities and integrate all three into programs for formal presentation to management, accompanied by specific recommendations for executive action.

Clarification of Ideas and Concepts: Evaluation of a new idea depends on a clear statement of the idea itself, in a form understandable to those who may be able to point out strengths and weaknesses. Opportunities for new products growing out of detectable market needs must be defined in very much the same way. Statements of the scope of product concepts link a descriptive title to a brief resume of the sponsor's thoughts and answer questions such as: What does the idea contribute by way of new function, improved function, or lowered costs? How is this accomplished? Why is this done in this particular manner? What alternative methods exist? Why was the proposed method selected?

Establishing Acceptability to Management: Top management should review proposed product-development programs prior to initiation of any major undertaking. Ideas that do not fit management's interests are removed from further consideration at this point. Since further activity on such programs wastes resources available for product development, any major effort should be deferred until an effective presentation can be prepared to establish management approval and support.

Management reaction to any new-product proposal is motivated by a number of factors, among which are the business outlook, corporate objectives, timing, and the individual likes and dislikes of top management. All of these have an important bearing on the general acceptability of ideas for new products. This is why an intimate familiarity with management thinking can be put to good use by the commercial-development division. Effective presentations reflect recognition of factors that have motivated past action by management.

Resolving Patentability: Controlling patents and licensing agreements should be identified and their scope and limitations established. This is essential to find what proprietary interests can be acquired in the new idea, and what steps are necessary to secure rights to permit commercial development of the idea.

New ideas, particularly those coming from outside, should not be submitted to technical groups until this step is completed. The commercial development-group can prevent premature disclosure of ideas to the technical organization and avoid unwarranted disclosure of company thinking about new products. Work conducted in the course of development programs may parallel that suggested by proposed ideas. Where this is the case, it is essential to establish proof of this fact prior to entering into any negotiations which include the company's scientists and engineers. Disclosure of the commercial feasibility of proposed ideas seriously complicates negotiations for their acquisition.

One important question to be resolved by the commercial-development division is whether patentability is essential to the commercial success of the venture. When patentability is essential, the question is: Can it be patented? This analysis is best centralized in the commercial-development division where dollar signs can be attached to the various factors in decision making.

Evaluation of Technical-Economic Factors: In giving definition to proposed programs, the group must examine technical and economic factors. Each has a direct bearing on the other. The object is to examine an idea in the light of available knowledge so that time and money will be spent only on programs that are relatively good risks. As evidence bearing on the relative commercial feasibility of ideas is brought into focus, product programs can be directed into the most productive channels.

Technical-economic investigations should explore each of the following areas:

1. Outlook for the industry identified with the proposed product
2. Important features of the proposed product
3. Effect of patents and licenses upon introduction of the product
4. Effect of a proposed product upon relationships growing out of products currently offered
5. Market for the product
6. Distribution for the product
7. Competition to be anticipated
8. Estimated costs and potential profits
9. Threat presented by future technological development

In the development of resource material for decision making, it should be remembered that factual information desired usually is not available; in most instances it does not exist. This is often overlooked in efforts to prepare reports that are "loaded" with factual data.

Overzealousness in a search for facts, in case after case, has resulted in rejection of opinions and observations of well-informed men whose comments, in the long run, are worth far more than factual data.

Day-to-day programs can be guided by decisions based on facts. However, programming for the future must be based on a different type of guidance. Far-sighted business planning calls for vision—not historical facts. This is the difference between a market study and a study of market opportunities.

Those responsible for long-range planning should insist upon evaluation in the light of conditions that will exist as these programs unfold, rather than against current conditions. There is some basis for suggesting to the investigator that he forget the past entirely, that he forget facts, that instead he seek out men who have capacities for intuition, discernment, analysis, and judgment. Observations of such men are worth more than files full of data.

Such an approach does not reduce the work load of the investigator. It is more difficult to locate such individuals than to locate factual data. One sometimes suspects that the reason reports are so frequently weighed down with data is that it is easier to dig up data than to find good thinking.

Picking men of vision is not an easy job. Familiarity with different areas of business activity reveals from time to time the men who have the capacity to project their thinking forward into the future and call the turns most of the time. Some common characteristics of such men are:

1. A naturally questioning approach to all matters coming within their view
2. Acute powers of observation
3. Capacity to concentrate on problems
4. Ability to associate ideas and facts in new relationships—the key to projecting thinking forward with a high degree of accuracy

It is doubtful that anyone has developed a formula which is a reliable indicator in selecting men who have the ability to take leadership positions in long-range thinking and planning. Best guide to use in selecting such individuals is past performance.

4. Decision Making

The commercial-development group does not make final decisions. Data are digested for management review and decision since management can not find time to review and analyze all the facts which must enter into decision making. The commercial-development group has the responsibility of preparing program presentations to management in a way that will minimize demands upon management time. Therefore, some decisions must be made by the commercial-development group. By their acts of commission or omission, decisions of far-reaching significance may be affected. For this reason, management must have full confidence in the ability and capacity of the group.

Management, with the help of the group, should establish objectives and criteria for future programs to permit greater effectiveness of the group.

Formulas, profiles, ratings, and other systems have been devised to evaluate proposed programs. All are spectacular but not spectacularly successful.

It can be seriously questioned whether or not these systems actually work in practice. A review of a number of programs where rating systems are reported to have been used leads to the conclusion that at best they played only a minor role.

Some rating systems have been adopted with great enthusiasm and later it appeared that they were not tailored to the job. They were then set aside. After subsequent conclusions were reached, the system was dusted off, the facts put in place and the rating system revised to substantiate the program adopted.

In these cases, the actual evaluation system appears to grow out of the individual programs. The evaluation, rather than proceeding from the general to the specific, has commenced with consideration of the specific problem and gone on from this point. This is particularly significant because it indicates that danger lurks in the shadow of any generalized plan for evaluating programs.

Another common problem associated with evaluation of programs is tied to the practice of basing decisions on the relation between returns (sales less costs) and total investment in the project. Such a basis of evaluation neglects any consideration of the time value of money. Recognition of the association between investment of funds and existence of alternate investment opportunities, with associated rates of return, is essential. When sizable sums are involved, the time value of money is appreciable and becomes an important element in evaluating programs.

5. Direction of Development Programs

Responsibility for co-ordination and direction of development programs should be fixed and centralized. Until new programs can be assigned to one of the operating divisions, the development group is in the best position to give close attention.

In the best-planned programs, problems will arise in the initial stages that demand top-management attention. The commercial-development group can bring problems to the attention of management and supply management with data needed in decision making.

▶ Organization of the Development Group

The commercial-development division should be organized to permit problems and proposals to receive individualized attention and at the same time be subject to review by experts where necessary. Most effective way of achieving this is by assigning individual programs to project supervisors and then making the services of specialists available to them.

THE PROJECT SUPERVISOR is given complete charge of specific assignments. His staff complement is determined by requirements of the assignment, and services of market, product, and economic-advisory groups are made available. He is permitted to exercise his own discretion in the use he makes of these services.

Although the project supervisor is responsible for the completed assignment, either the project director or the executive officer may ask members of the economics, market, or product staff to review reports and comment. This double check assures that all programs are given breadth and depth in analysis.

The Staff Supervisors are responsible for developing thorough knowledge and background in their respective areas. Therefore, their training and experience should reflect specialization and competence. While project supervisors are responsible for assigned projects, staff supervisors are responsible for calling to management's attention specific matters of significance that are developing within their respective areas.

The Economic-Analysis Supervisor is responsible for keeping management informed of impending changes in business conditions. Every available resource should be exhausted in fulfilling this responsibility. Specific functions assigned fit into four categories:

1. Development of industry trends
2. Business-conditions analysis
3. Development of corporate-acquisition programs
4. Development of business-development programs

The last two responsibilities are shared with market and product supervisors. Staff members in each area should concentrate part of their effort in a search for new opportunities for potentially profitable new business or desirable acquisitions.

The Market-Analysis Supervisor is responsible for development of market information. Project supervisors and management need a source to which they can turn for competent counsel in this highly important area of specialization. The market-analysis supervisor is responsible for:

1. Consumer preference and demand studies
2. Development of corporate-acquisition programs
3. Development of business-development programs

Exercising this responsibility entails full use of outside sources of information in conjunction with work of an adequately staffed market-analysis group, reporting directly to the market-analysis supervisor.

The Product-Analysis Supervisor is principally concerned with physical products and their relationships. His activities fall into six broad areas:

1. Search for new-product ideas
2. Appraisals of product performance
3. Analysis of product lines and product "mix"
4. Definition of potentially profitable products
5. Development of corporate-acquisition programs
6. Development of business-development programs

The product-analysis supervisor should have a high degree of technical competence and his staff a wide range of technical competence. To operate effectively, the commercial - development division must be able to evaluate significance of new technology.

The Staff Director has an administrative responsibility and a somewhat broader function in counseling management and members of the project group. From an administrative position, the staff director is responsible for professional competence of the three groups and their effectiveness in completing assignments as needed. In his broader function, acting as counsel to management, he has six areas of responsibility:

1. Evaluation of the relative commercial feasibility of proposed research and engineering programs and new-product concepts
2. Co-ordination of business-development programs
3. Surveys
4. Consultation services
5. Development of corporate-acquisition programs
6. Development of business-development programs

Individual assistance requested from the three staff supervisors is provided directly. Problems of extreme breadth place the staff director in the position of program co-ordinator.

The Executive Officer of the commercial-development department has full responsibility for all activities, maintaining operations at a level commensurate with the total company effort and making certain that the department's potential contributions are fully utilized. This is a continuing counseling responsibility in itself.

In the final analysis, commercial development is a management service. Research and engineering managers need reliable commercial counsel to operate effectively. Top management needs assistance of unquestionable reliability. To assure a communication pattern that adequately informs, interprets and advises, commercial "intelligence" should be centralized.

Bibliography

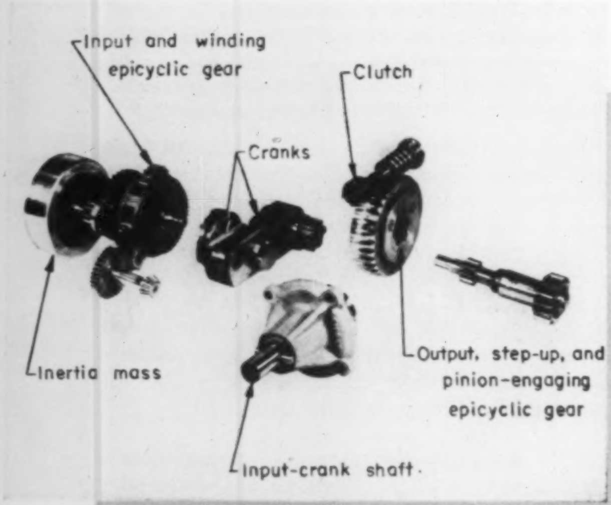
This article, and two preceding articles, cover completely the organization required for adequate management of new-product development. Those two articles are "Research for Results" (October 17) and "How to Organize Engineering for Product Development" (December 26). They are a continuation of a coordinated group by Dr. Marvin that covers all phases of new-product development. The other articles are:

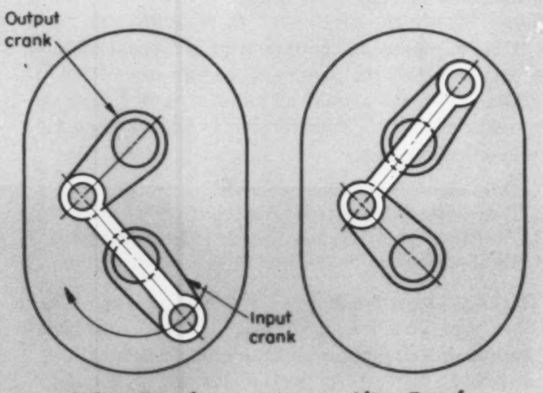
"Planning Product Strategy" ....June 13, 1957
"Developing Ideas for New-Product Programs"........July 11, 1957
"Profitable Fields for New-Product Development"..August 8, 1957
"Screening and Appraising New-Product Ideas"..September 5, 1957

They Say . . .

"Somehow, large engineering organizations must develop group insight and intuition and the capacity to respond quickly to new situations, both in the scientific field and in their markets. A major factor in the solution of this problem will be more effective means of communication which in turn requires clear understanding at both ends of the communication channel. The managers of technical businesses will require broader technical knowledge to understand and appraise the specialists and the specialists will need a better knowledge of the business to understand and aid the managers."—Morrough P. O'Brien, *dean, College of Engineering, University of California, Berkeley, Calif.*

scanning the field for *ideas*


Input and winding epicyclic gear
Clutch
Cranks
Inertia mass
Output, step-up, and pinion-engaging epicyclic gear
Input-crank shaft

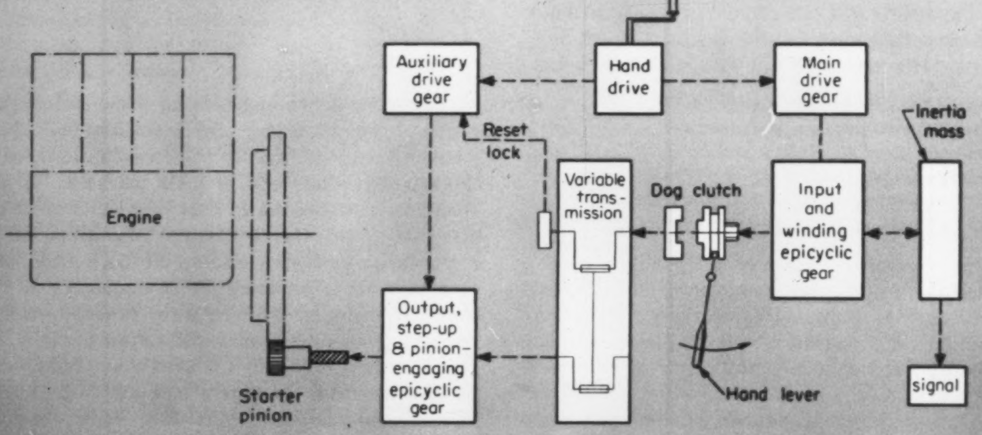

Output crank
Input crank

Before Transfer

After Transfer

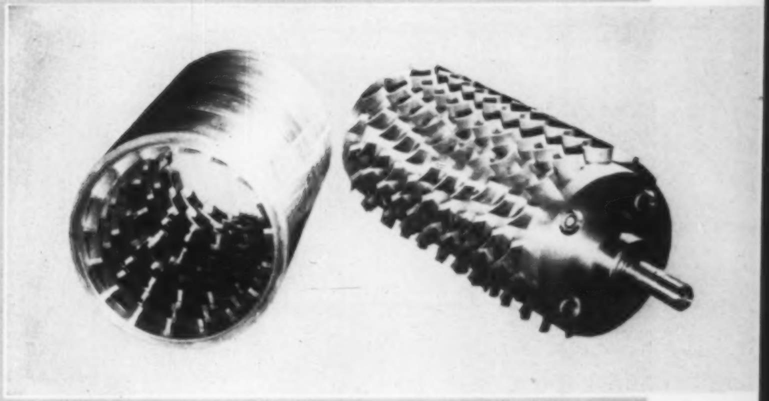
Rapid energy transfer from one rotating mass to another is accomplished smoothly and efficiently by a modified four-bar linkage. After transfer of momentum, one mass has accelerated to the original speed of the other, which has decelerated to zero speed. Developed by Inertia Starter Developments Ltd., London, for a diesel-engine inertia starter, the design consists of a connecting rod, and input and output cranks which are limited in angular movement between their extreme positions.

In the initial position, the axis of the connecting rod passes through the axis of the input crank, while in the final position it passes through that of the output crank. During this change in positions, the "gear" ratio between the two cranks changes progressively from a starting value that approaches ∞:1 to a final value that is substantially 1:∞.

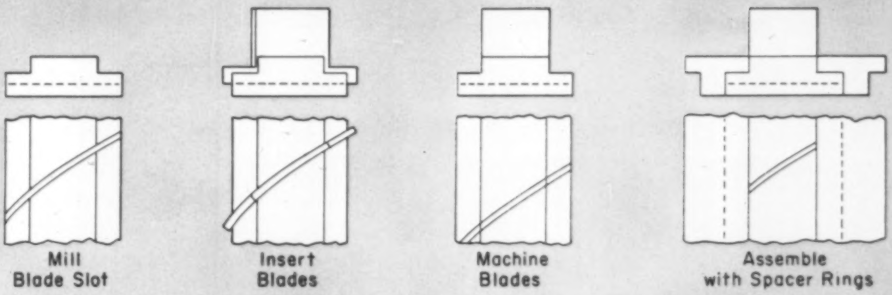

Auxiliary drive gear
Hand drive
Main drive gear
Inertia mass
Reset lock
Variable trans-mission
Dog clutch
Input and winding epicyclic gear
Engine
Output, step-up & pinion-engaging epicyclic gear
Starter pinion
Hand lever
signal

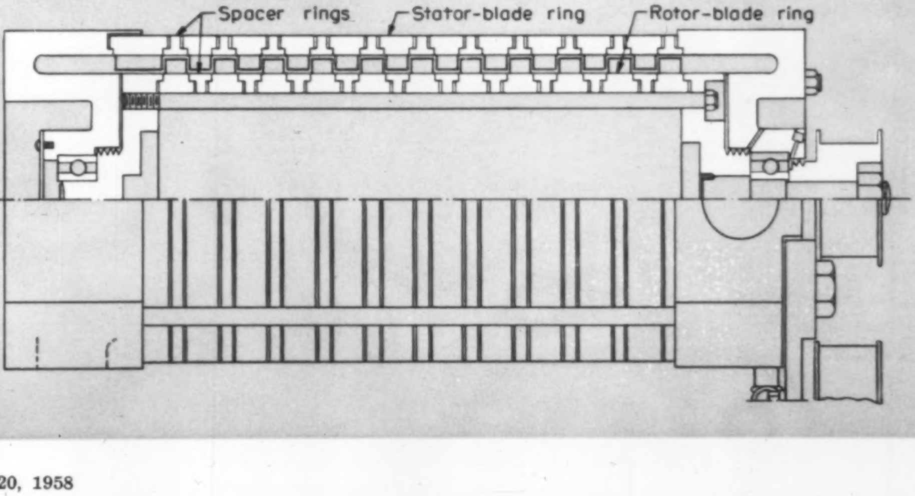
Ring construction of rotor and stator sections in an axial-flow compressor cuts time and cost of blade fabrication and assembly, and offers flexibility in design. Developed by Latham Mfg. Co. for an automotive supercharger, the design permits use of low-cost, stamped blades, provides positive blade anchorage, and allows variation in number of stages employed. The rotor and stator are of similar construction, consisting of blade rings, stamped blades, spacing rings, and means for locking the individual rings together to form a unit.

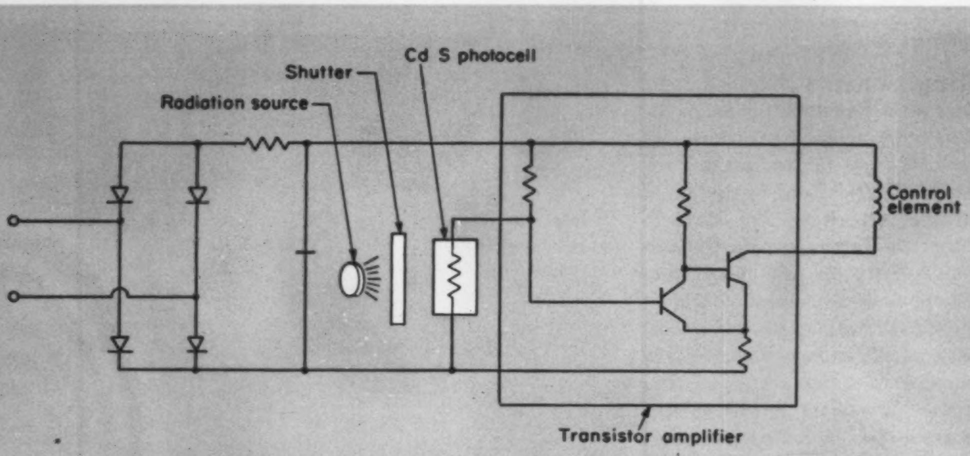
Each blade ring has a T-shaped cross section and is milled with curved slots for the individual blades. The curved blades, also T-shaped, are inserted into the slots and then the sides and flanges are machined flush with the blade rings. The spacer rings provide the proper dimension between stages and also serve as a mechanical lock for the blades.



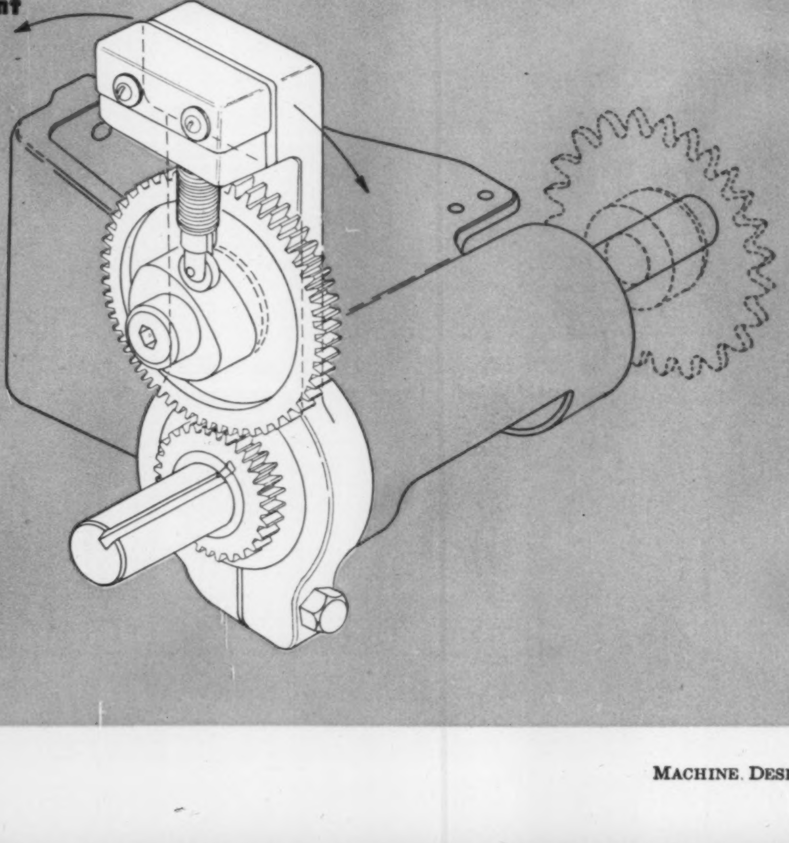
Blade-Ring Assembly


Mill
Blade Slot
Insert
Blades
Machine
Blades
Assemble
with Spacer Rings

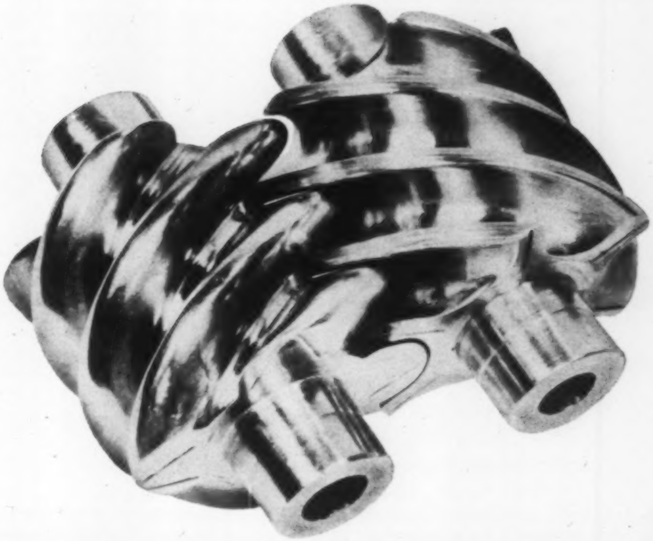

Spacer rings
Stator-blade ring
Rotor-blade ring



Solid-state photoelectric system offers flexibility of control with high reliability for use in relatively inaccessible locations. Developed by Westinghouse Electric Corp., the system employs a strontium-90 radiation source and a detector. Detection occurs upon decrease in resistance of the photocell in the presence of radiation. The cell is incorporated in a bistable transistor-amplifier circuit whose output depends upon the cell resistance. When that resistance falls below a certain level, the output changes instantaneously from off to on, actuating a control circuit.

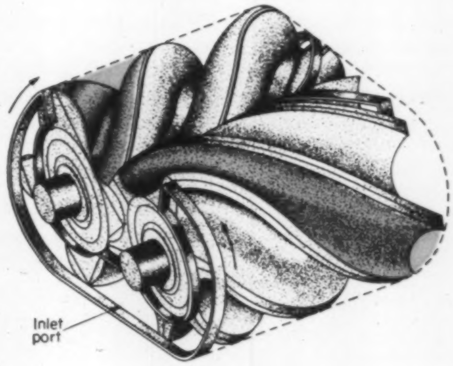


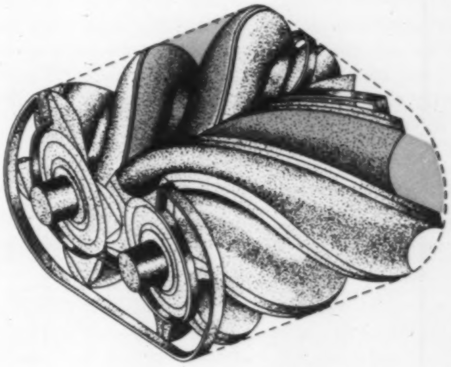
Phase adjustment between a cam and an external drive shaft is provided by a movable cam-follower system. In the design, developed by Macey Co., the driven gear and cam assembly and the cam follower are mounted on a movable bracket that is fitted to the drive-gear housing. Rotation of the bracket permits angular displacement of the cam-follower system, varying the timing relationship between cam and drive gear.

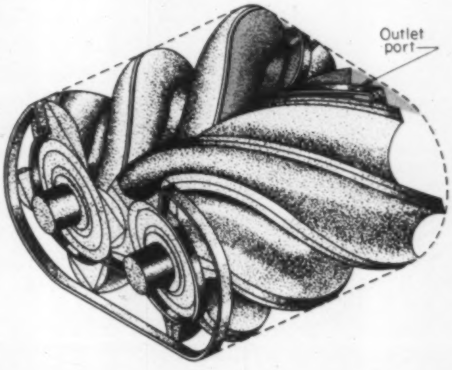


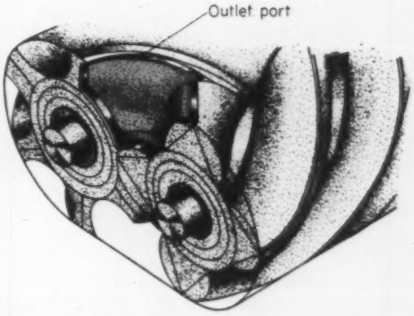
Screw-rotor design for compressor applications offers characteristics of a positive-displacement system with rotary operation. Design of the Heli-Rotor compressor employs two gear-like members, one with helical male lobes and the other with mating gullies. During rotation, the lobes successively pass along the female gullies, compressing entrapped air and moving it from inlet end of the housing to the outlet.

Just before leaving the inlet port, each gulley is entirely open to incoming air. Rotation carries the air-filled gulley circumferentially around the housing until it meshes with the male lobe, compressing the air and forcing it toward the outlet end. After the air has been compressed, further rotation of the meshing members uncovers the outlet port and the chamber is evacuated. The unit was designed by Stratos Div., Fairchild Engine & Airplane Corp.







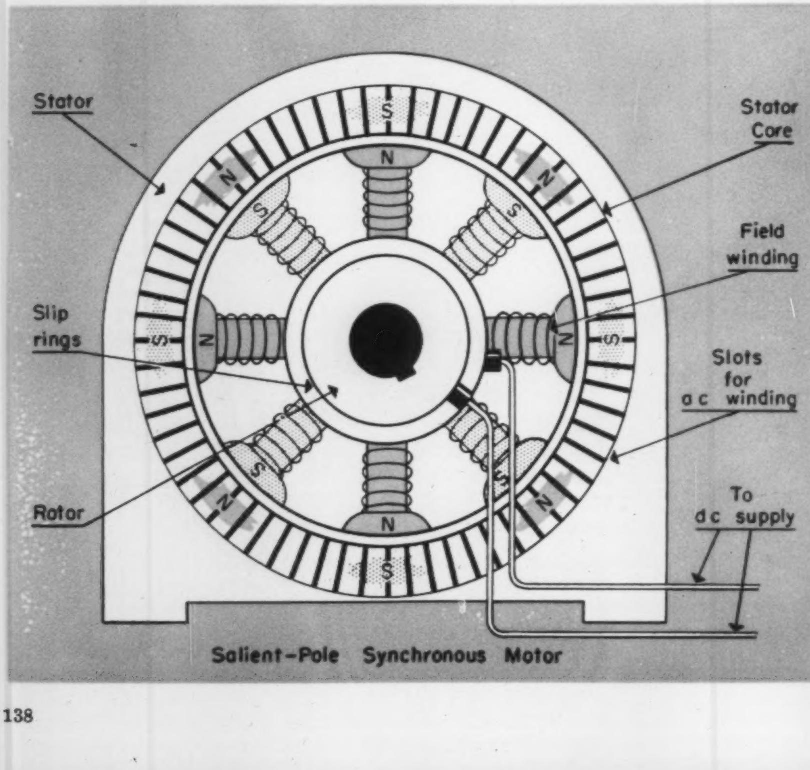


Methods of
Starting Synchronous Motors

BEFORE any motor can be used, means must be provided to connect it to a power source, control its acceleration, and stop it. Also, the winding in the motor must be protected against damage from thermal overload or from electrical faults. Controls for synchronous motors must accomplish all of these primary functions. In addition the control equipment must also apply dc excitation at the proper speed and the proper angle at pull-in, to promptly remove field excitation on pull-out, and to protect its squirrel-cage winding against thermal damage under stalled conditions or when operating at subsynchronous speed. All of these functions must be performed efficiently and economically without penalizing the motor by distorting its characteristics.

Full-Voltage Starting: Any of the conventional starting methods used for squirrel-cage motors may be applied to a synchronous motor. Full-voltage starting is, of course, the simplest and the most economical in cost of equipment, cost of power involved in starting, and in time required to accelerate. However, full-voltage starting requires the motor windings to be sufficiently braced, and the mechanical structure of the motor, the connected load, and the coupling to be of sufficient strength to withstand the stresses produced by the high inrush current and the sudden application of maximum starting torque.

Part-Winding Starting: Some motors with multiple-circuit windings may be started at full voltage



A synchronous motor is basically a constant-speed motor that is started by a squirrel-cage winding and then locked "in-step" by a dc current applied to the field winding. The motor is started as a squirrel-cage motor by ac power. When the motor has reached synchronizing speed—approximately 95 per cent synchronous speed—dc current is introduced into the field windings in the rotor. This dc current creates constant-polarity poles in the rotor which cause the motor to operate at synchronous speed.

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by energizing successive portions of the winding until the full winding is in use. The starting current and the starting torque are thus reduced in various combinations of increments depending on motor design and the requirements of the application. Fig. 1 shows typical power connections of one phase of a part-winding starter.

Autotransformer Starting: Reduced-voltage starting methods include such types as primary resistor, primary reactor, autotransformer, wye-delta, etc.

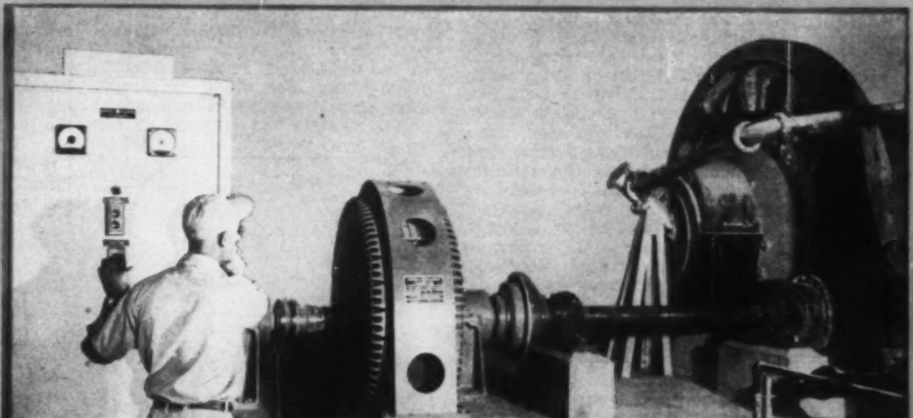
An autotransformer applies to the motor a voltage less than line voltage in proportion to the turn ratio of the transformer. This is the most efficient method of reducing motor current during starting, but is usually the most expensive. Standard taps on the autotransformer provide 50, 65, or 80 per cent voltage to the motor, and this voltage is practically constant (with constant line voltage)

Synchronous motors possess the obvious characteristic of constant-speed operation, providing line frequency remains constant. Typical drive applications for synchronous motors are motor-generator sets, compressors, pumps, blowers, etc.

Synchronous motors are also employed for power-factor correction in industrial electrical systems. Unity power factor in a plant permits higher operating efficiency of all motors and lowers starting currents.

Synchronous motors discussed in this article are single-speed, polyphase machines with salient-pole rotating fields. Motors of this design are practically always built in integral horsepower sizes. Low starting torque and the need for a separate dc power source for excitation are sometimes considered disadvantages for synchronous motors of this design.

There are three factors of prime importance to consider when selecting controls for these types of motors: 1. Full motor protection while starting. 2. Accurate field application. 3. Dependable field-removal system. These requirements are covered in detail, and several methods of starting synchronous motors, which meet these requirements, are presented.



Salient-pole, 500-hp synchronous motor, driving a ball-type raw grinding mill at the Idaho Portland Cement Co., Inkom, Idaho.

throughout the starting period. Motor current is reduced in direct proportion to the tap voltage, but current drawn from the line varies as the square of the tap voltage, if transformer magnetizing current is neglected. Starting torque is reduced in the same proportion as line current. Therefore torque developed per ampere of line current (torque efficiency) is the highest of any method of reduced voltage starting.

Fig. 2 shows the power circuit to the motor using

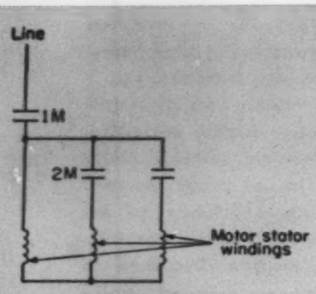


Fig. 1—One phase of a three-step, part-winding starting control.

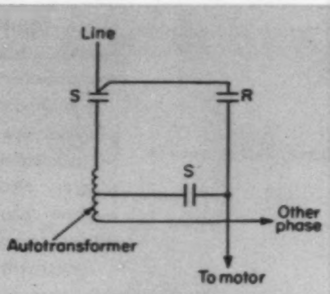


Fig. 2 — Autotransformer starting control with open-circuit transition.

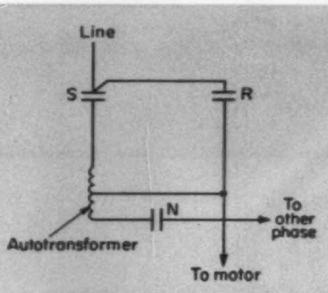


Fig. 3 — Autotransformer starting control with closed-circuit transition.

Synchronous Motor Operating Characteristics

Applying and removing dc field excitation to a synchronous motor at the proper time is critical. The motor will stop if the field is applied before pull-in speed is reached. Likewise, the field must be applied when the phase angle is just right to effect pull-in. If pull-in is delayed for any reason, a large current is drawn from the line. If the motor pulls out of synchronism, the field must be removed immediately.

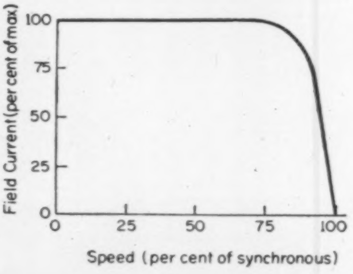
This discussion covers in detail these and other electrical starting, running, and stopping characteristics of salient-pole synchronous motors. With these operating phenomena well in mind, the designer can better select a starter that will meet the exacting starting and stopping control a synchronous motor of this type requires.

Rotor and Stator Windings: In a salient-pole, polyphase synchronous motor, the currents circulating through the distributed stator winding produce a flux which will rotate around the air gap at a speed directly proportional to the frequency of the power supply and inversely proportional to the number of pairs of poles in the winding.

The rotor is built with the same number of poles as the stator, and an external source of dc power is connected to the rotor winding, which produces a flux of fixed position relative to the rotor. These poles are attracted by poles of opposite polarity in the rotating magnetic field produced by current in the stator. Thus the machine will operate at the same speed as that of the rotating stator flux after it has been accelerated to near that speed. As long as the machine continues to run in synchronism, its average speed will be constant, since the poles of the stator and rotor are locked together magnetically; the only way to change its speed would be to change the frequency of the power supply.

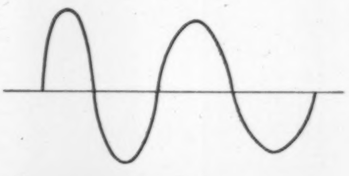
When the rotor is at standstill and ac voltage is supplied to the stator, a relatively high voltage is induced in the rotor winding by transformer action. To limit this induced voltage to a safe value, the field winding is short-circuited through a resistor. The current, which is caused to circulate by this induced voltage, will produce a small torque at standstill and an appreciable component of total torque near synchronous speed. The same resistor used for starting will also serve to absorb the inductive "kick" developed and to discharge the field when the dc circuit is opened.

If dc is supplied to the rotor and ac to the stator, the motor will develop a large oscillating torque but will not accelerate from standstill. To start the machine it is necessary to add a squirrel-cage winding to the rotor and to short circuit the field winding. Under these conditions the synchronous machine will start and accelerate nearly to synchronous speed just as an ordinary squirrel-cage induction motor, but it cannot pull into synchronism. There are cases where salient-pole synchronous motors may be able to accelerate a fraction of their rated loads into synchronism and to carry this load in synchronism without excitation merely on reluctance torque, but these are the exception rather than the rule. Dc voltage is then applied to the field winding, and the machine pulls into step and continues to run at synchronous speed. The squirrel-cage serves merely as a damper winding to reduce the instantaneous speed variations caused by sudden changes of load or fluctuations of line voltage. Since the squirrel-cage winding serves primarily to start the motor and practically no currents are induced in it after it has synchronized, this winding need not be designed for the heavier duty normally required of induction motors.



a—Average current in field winding during acceleration from zero speed to synchronous.

Field Voltage: Frequency of induced voltage in the field winding during acceleration is determined



b—Field current near synchronism showing the decreasing frequency characteristic.

an autotransformer for reducing the voltage during start. Contactor S may be a five-pole device to connect both the motor and the line to the autotransformer. After the motor has accelerated, contactor S is opened and contactor R is closed which applies full voltage to the motor. This method opens the circuit to the motor during the transition from reduced to full voltage. This is necessary to prevent S and R from being closed at the same time and short circuiting a part of the autotransformer.

A closed-circuit transition can be accomplished by the circuits in Fig. 3, in which contactors S and N are closed initially for starting. After acceleration, N is opened, R is closed, and then S is opened. By this method the motor remains connected to the line through S and a part of the autotransformer as a series impedance during the change from reduced to full voltage. Autotransformer starting is usually limited to two steps of starting—one step at reduced voltage and the final one at full voltage. Increments of successively higher voltage during start would complicate the control beyond economic limits because of the switching of taps and the need to avoid short-circuiting any part of the autotransformer.

When the motor is first connected to the line there is a transient peak of current above the steady-state locked-rotor inrush. This transient peak is of short duration and in the case of reduced voltage starting is limited to a value below that of full-voltage inrush. With open-circuit transition from a reduced-voltage start, the current must first decay to zero, followed by another transient peak when the motor is connected at full voltage. This transient at throw-over may be several times as great as that which would have been obtained if the machine had been energized at full voltage initially. This comes about because the throw-over may be rapid enough to trap some of the rotor flux which can be somewhat out of phase with the oncoming voltage due to drop in

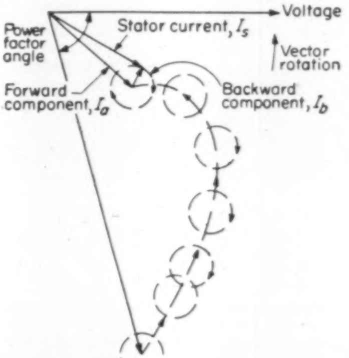
Affecting Control Selection and Application

by the difference in speeds of the rotor and the stator. This frequency varies from line frequency at standstill to zero at synchronous speed.

Chart *a* shows the variation of induced field current with speed during acceleration of a typical synchronous motor. The value of this current remains fairly constant up to around 75 per cent speed and drops to approximately one half at 95 per cent speed for this example. This characteristic may vary widely from one machine to another. The decreasing frequency of this current as speed is increased near synchronous speed is illustrated in curve *b*.

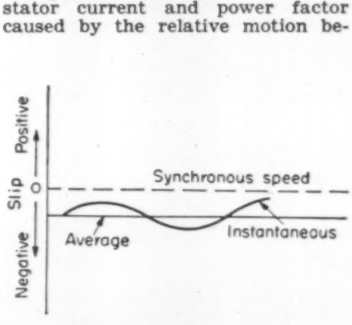
Stator Current: Under locked-rotor conditions, the ac line current is a maximum and the power factor is a minimum. As the rotor accelerates, the stator current decreases in magnitude and the power factor improves, reaching its maximum somewhere in the range of 80 to 90 per cent speed. Because of the salient-pole effect, the stator current is modulated at a frequency which varies from a maximum of one-half line frequency at 25 and 75 per cent speeds to zero frequency at standstill, half speed and full synchronous speed.

In drawing *c* is the vector diagram of one phase of stator current during acceleration. The stator current is made up of two components—the forward component and the backward component. Near synchronous speed the backward component rotates at twice slip frequency. The locus of the tip of the stator current vector forms a spiral from the instant of start to maximum speed as an induction motor.



c—Vector diagram of one phase of stator current during acceleration depicting the decreasing power-factor angle.

Power Factor: The effect of the salient poles on the rotor is to change the instantaneous values of stator current and power factor caused by the relative motion between the magnetic poles of the stator winding and the salient poles of the rotor. As the magnetic poles of the stator pass the iron core of the rotor poles, the flux meets a varying magnetic reluctance. When the axis of the magnetic field of the stator coincides with the axis of the rotor poles, the magnetic reluctance is low. Therefore, the reactance, which is proportional to the frequency and the reluctance, is high, the current in the stator is a minimum, and the power factor is poorer than average. Likewise when the axis of the stator magnetic field lies between two rotor poles, the reluctance offered to the flux is a minimum and the impedance is lower than the average. Under these conditions, the stator current is higher, but since the reactance is a lower percentage of the total impedance, the power factor is also higher than average.



d—Average and instantaneous slip near synchronous speed.

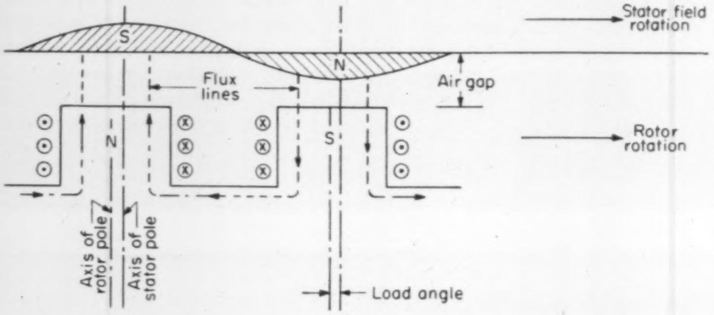
Slip: As the rotor increases in speed, the time required for a stator magnetic pole to pass two rotor poles increases and consequently a so-called "slip cycle" becomes longer as the relative angular velocity between the stator field and the rotor poles becomes less.

The rotor finally reaches the speed as determined by the torque developed as an induction motor and by the load torque. Under these conditions there is an average rotor speed beyond which as an induction motor the machine cannot bring its connected load. At this condition, the rotor instantaneous speed is not constant, but varies from a maximum to a minimum depending on the relationship of the stator magnetic field and the salient poles of the rotor, as shown in diagram *d*. The average slip and

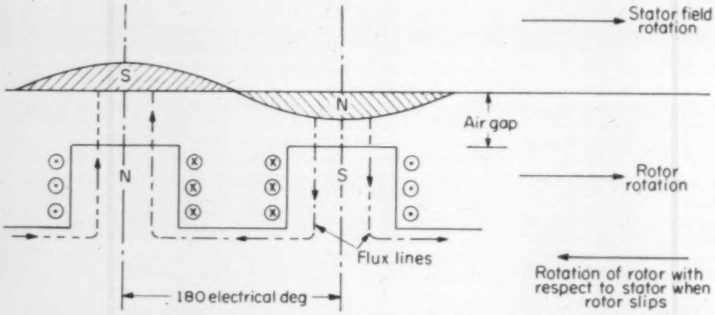
Synchronous Motor Operating Characteristics *(Continued)*

the instantaneous value of the minimum slip to which the machine, acting as an induction motor, can bring its inertia and its connected load is very important and strongly affects the ability of the motor to synchronize. If this minimum slip is not reached the motor will not be able to synchronize its connected load. This is true irrespective of the time or angle at which the excitation is actually applied. The control equipment must, therefore, automatically and accurately insure that this speed has been reached before attempting to close the dc circuit, if successful synchronization is to be obtained.

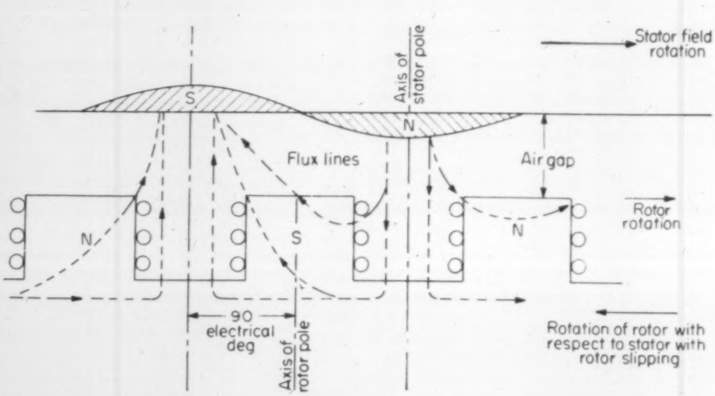
Torques and Synchronization: The torques built into synchronous motors are: 1. Starting or break-away torque. 2. Accelerating torque. 3. Pull-in or synchronizing torque. 4. Running torque. 5. Pull-out or break-down torque. For a given motor design, these torque characteristics are generally fixed.



e—Position of stator and rotor poles while operating under load in synchronism.



f—Position of stator and rotor poles before synchronizing with axes coinciding. Under these conditions, flux linkages are at a maximum, reluctance is low, stator current is at a minimum, and induced field voltage is zero.



g—Position of stator and rotor poles before synchronizing with axes displaced 90 deg. Under these conditions, flux linkages are at a minimum, reluctance is high, stator current is at a maximum, and induced field voltage is at a maximum value.

The designer of the control equipment may alter some of these characteristics to fit the requirements of a particular application. For instance, the limitations of a user's power system or of the driven machine may require a starting torque (current) below that which the motor is capable of producing, or certain lower levels of accelerating torque peaks may be necessary. Seldom, if ever, however, would there be occasion to reduce the pull-in torque. The rule is to obtain and use all the pull-in torque the motor can produce to synchronize its load.

Pull-in torque is the maximum constant-load torque against which the motor will pull its connected inertia load into synchronism when dc field excitation is applied. After the motor has reached its maximum speed as an induction motor, the second most important consideration is application of field at the correct angle between the axes of stator and rotor poles. In sketch *e* is a pair of poles in stator and rotor under loaded synchronous-speed operation with excitation applied. The axis of the rotor poles is displaced backward (in the motoring quadrant) from the direction of rotation of the stator field by an angle called the "load" angle. Here there is a large number of flux lines linking the rotor to the stator like rubber bands tieing the two together, stretching or shrinking with change of load. If the load becomes too great, the load angle becomes so large the flux linkages (rubber bands) break and synchronism is lost.

Sketch *f* shows an instantaneous condition before synchronous speed has been reached, with the field circuit still short circuited through its resistor and with the axes of stator and rotor poles coinciding. The direction of travel of both the rotor and the magnetic field of the stator is toward the right. But the rotor is moving slower than the stator field, so its travel relative to the stator is toward the left. Hence the poles of the rotor are passing the poles of the stator, or vice versa, and the effect of power factor and current pulsation previously described is obtained because of the salient-pole construction which produces a variation in reluctance of the magnetic path. In the position shown the reluctance is low which allows high flux linkages and the stator current is a minimum because of the higher reactance. At this point, the flux linking the rotor with the stator is not changing and the voltage induced in the field winding is therefore zero.

Illustration *g* is the same as *f* except that the rotor poles have moved backward 90 electrical degrees. Here the reluctance of the magnetic path is a maximum, consequently the flux is a minimum, stator current is a maximum and the induced field voltage is a positive maximum. It is evident that speed during the period of transition when the motor was disconnected. Closed-circuit transition will eliminate this added transient peak since the motor is not disconnected, and therefore the rotor will not get out of phase.

Primary Resistor Starting: In the primary resistor type of starting, reduced voltage is obtained by inserting a series resistor betwen the line and the motor. A resistor in each phase will keep the phase currents balanced. This is a voltage-drop method, the actual voltage applied to the motor depending upon current drawn by the motor. These resistors are shorted out in one or more steps until full voltage is applied. The number of steps and the timing between steps will be determind by power-system limitations and/or torque requirements. Motor current will be the same as current drawn from the line. Starting torque will be reduced by the ratio of applied motor voltage squared to line voltage squared. This is a closed-circuit type of starting, which is lower in cost and efficiency than autotransformer starting, but the power factor is higher.

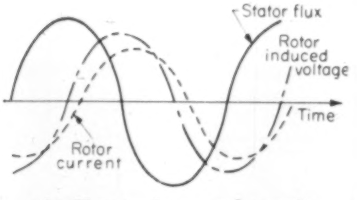
Primary Reactor Starting: A series reactor in each phase of the power supply can also be used to obtain reduced voltage at the motor. After acceleration, the reactor is shorted out. As in the autotransformer, this method is usually limited to two steps of start, unless open-circuit transitions are resorted to between steps. Impedance drop through the reactor results in a reduced voltage at the motor. As the motor accelerates, the drop across the reactor decreases, the power factor increases and the reactor drop swings out of phase with the motor voltage. The voltage at the motor thus increases as speed increases. The torque varies as the square of the motor voltage.

Wye-Delta Starting: Although it is often classed as a reduced voltage type, strictly speaking wye-delta starting is a full-voltage method. Both ends of each motor phase winding must be brought out so that full voltage may be applied to them connected first in wye, then after acceleration, in delta. This requires that the machine be designed for normal operation with delta-connected windings. The current drawn from the line and the torque developed by the motor when wye-connected are both one-third of the delta-connected values, which

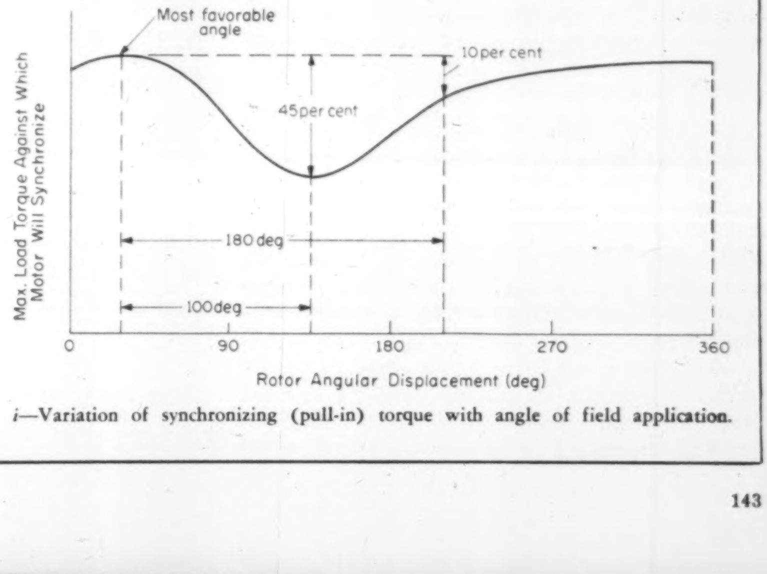
since the flux has decreased from a maximum in one direction, as shown in sketch *f*, and will increase to a maximum in the opposite direction, its rate of change must be maximum. Since induced voltage is proportional to the negative rate of flux change, the voltage induced in the field winding is a maximum at this point and will be in such a direction as to oppose the action which produced it. In other words, this voltage will tend to maintain the flux and oppose its further decrease.

Because the field circuit is an inductive circuit, the voltage induced in it will cause a current to flow which will lag the voltage by some angle depending upon the ratio of reactance to the sum of the resistances of the field winding and the external discharge resistor. Diagram *h* shows the induced field voltage and the circulating field current produced by it. Note again from sketch *e* that the synchronous condition is indicated by high flux linkages between the stator and the rotor. It follows that the most favorable condition under which to apply field excitation would be at a point where high flux linkages had already been established, provided the oncoming excitation produces a flux in the same direction as that of the existing flux. It was shown in sketch *f* that at that instant the stator flux tended to be a maximum but the current produced by the voltage induced in the field winding also produces a flux which opposes the stator flux linkages and actually reduces them in magnitude. But at the point where induced field current passes through zero, the flux produced by it is zero. Hence, the resultant flux linkages are a maximum. They must be a positive maximum, otherwise when pulling into step it will be necessary to reverse the flux from the negative to the positive direction which will result in poor synchronizing ability.

As shown in drawing *i*, pull-in torque varies with the angle between the axes of the rotor and stator poles at the instant of closing the excitation circuit. If the motor has first attained its highest speed as an induction motor (the minimum speed from which it can synchronize), maximum load can be pulled into synchronism when field is applied in the range of 15 to 30 electrical deg behind the no-load angle. At this point induced field current is zero and flux linkages are maximum. If the polarity of applied field current is in a direction to increase or add to the flux linkages already trapped, maximum pull-in torque will be developed. Minimum pull-in torque is developed approximately 90 electrical deg beyond this point.



h—Flux, voltage and current curves at constant slip before synchronizing.



i—Variation of synchronizing (pull-in) torque with angle of field application.

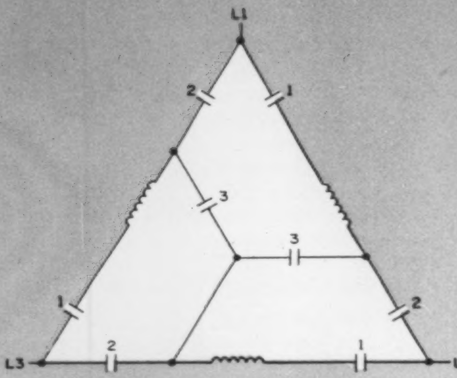


Fig. 4—Wye-delta starting control with open-circuit transition.

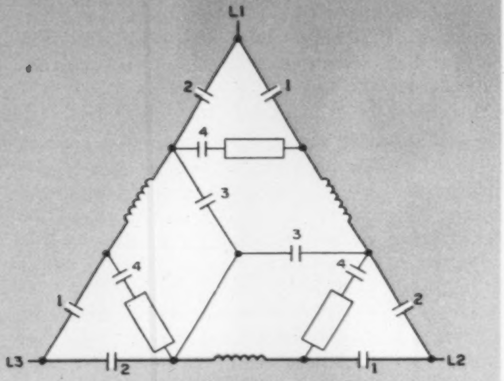


Fig. 5—Wye-delta starting control with closed-circuit transition.

results in these wye values corresponding closely to those of autotransformer starting on the 65 per cent tap. Since no external loss of power is involved in reducing the voltage, this method compares favorably with part-winding starting. The major disadvantage of wye-delta starting is that the starting torque is fixed for any motor design. Fig. 4 shows the power circuit of a normal wye-delta starter requiring two three-pole and one two-pole contactors. This requires disconnecting the motor from the line during the switching interval from wye to delta and results in the high transient peak of current when reconnected to the line. A closed-circuit transition and elimination of this switching transient is possible by use of the power circuit in Fig. 5. Note that a third three-pole contactor and a resistor have been added in this circuit as compared to Fig. 4. The control sequence is: 1. Motor windings connected in wye to the line. 2. Resistors connected in parallel with the phase windings. 3. Windings switched from wye to delta with resistors phase shifted and in series with motor windings. 4. Resistors shorted out. 5. Resistors disconnected.

In Table 1 are shown the starting currents and torques expressed as a percentage of full-voltage values for various starting methods and Fig. 6 shows typical speed-torque curves.

Field Excitation: Originally, equipment for starting motors was manually operated, but the trend has been more and more toward automatic control and protection of these rotating electrical machines. As applied to synchronous motors, the first attempts at automatic control were made in the synchronizing process. A timing interlock on the line contactor was used to close the field contactor. Then a lock-out coil was added to this interlock to prevent its closing until the induced field current had decayed to a certain value. In this way a degree of measurement of rotor speed

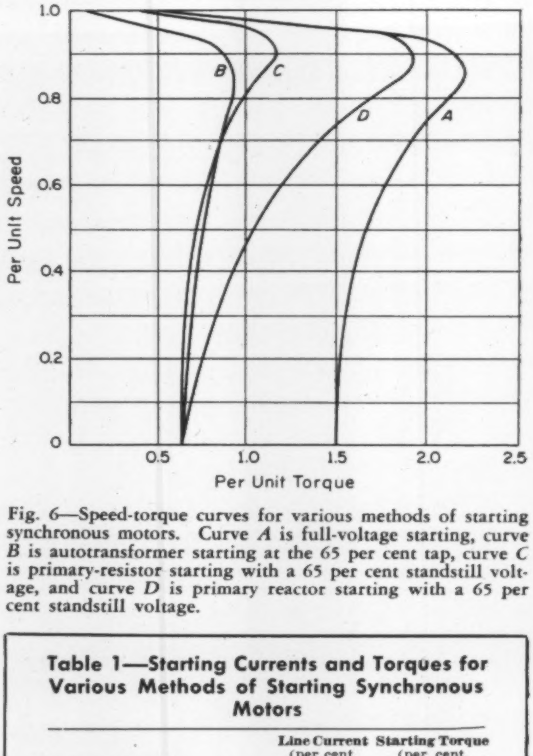


Fig. 6—Speed-torque curves for various methods of starting synchronous motors. Curve *A* is full-voltage starting, curve *B* is autotransformer starting at the 65 per cent tap, curve *C* is primary-resistor starting with a 65 per cent standstill voltage, and curve *D* is primary reactor starting with a 65 per cent standstill voltage.

Table 1—Starting Currents and Torques for Various Methods of Starting Synchronous Motors

Starting Method	Line Current (per cent of full)	Starting Torque (per cent of full)
1. Full Voltage	100	100
2. Part-Winding	Varies with motor design	
3. Autotransformer		
80 per cent tap	64	64
65 per cent tap	42	42
50 per cent tap	25	25
4. Primary Resistor		
80 per cent voltage to motor	80	64
65 per cent voltage to motor	65	42
50 per cent voltage to motor	50	25
5. Primary Reactor		
80 per cent voltage to motor	80	64
65 per cent voltage to motor	65	42
50 per cent voltage to motor	50	25
6. Wye-Delta		
Wye connection	33	33
Delta connection	100	100

was obtained, since a time delay alone was no assurance that the motor had started at all. The next step was to provide an automatic means of removing field excitation when the rotor pulled out of step for any reason.

Various schemes have been used to control the application and removal of excitation automatically, each successive scheme attempting to take full advantage of the motor's available characteristics to insure complete overall protection and fully automatic operation under all conditions of service. Slip-frequency of the rotor, amplitude of rotor current, amplitude of stator current, phase relation of stator current with line voltage, combinations of timing with these signals, etc., all have been tried and used both for synchronizing and for protection on pull-out. It is generally agreed that the signal obtained from the rotor during starting offers the best measure of speed and rotor position for synchronizing. However, a signal from this source used to initiate the removal of excitation on pull-out is too slow since the motor must already be out of step before any signal is produced. Once out of step, the speed, torque and current change extremely fast. Therefore, for protection against damage on pull-out a signal obtained from the stator offers the best solution.

In a General Electric system of field application both criteria of proper synchronizing are fully met. The complete circuit of a typical full-voltage starter is illustrated in Fig. 7. First, the length of succeeding half cycles of induced field current are measured to insure that the correct speed from which to synchronize has been attained. This method is a simple yet very accurate means of measuring rotor speed. Next the correct angle of

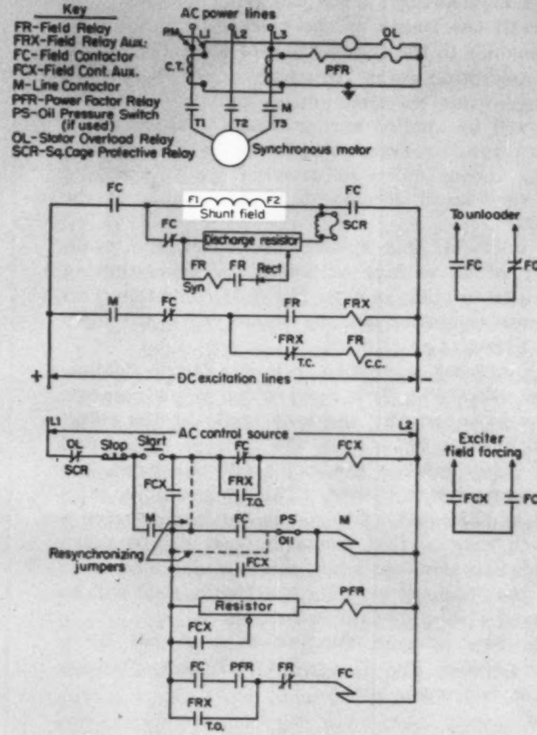
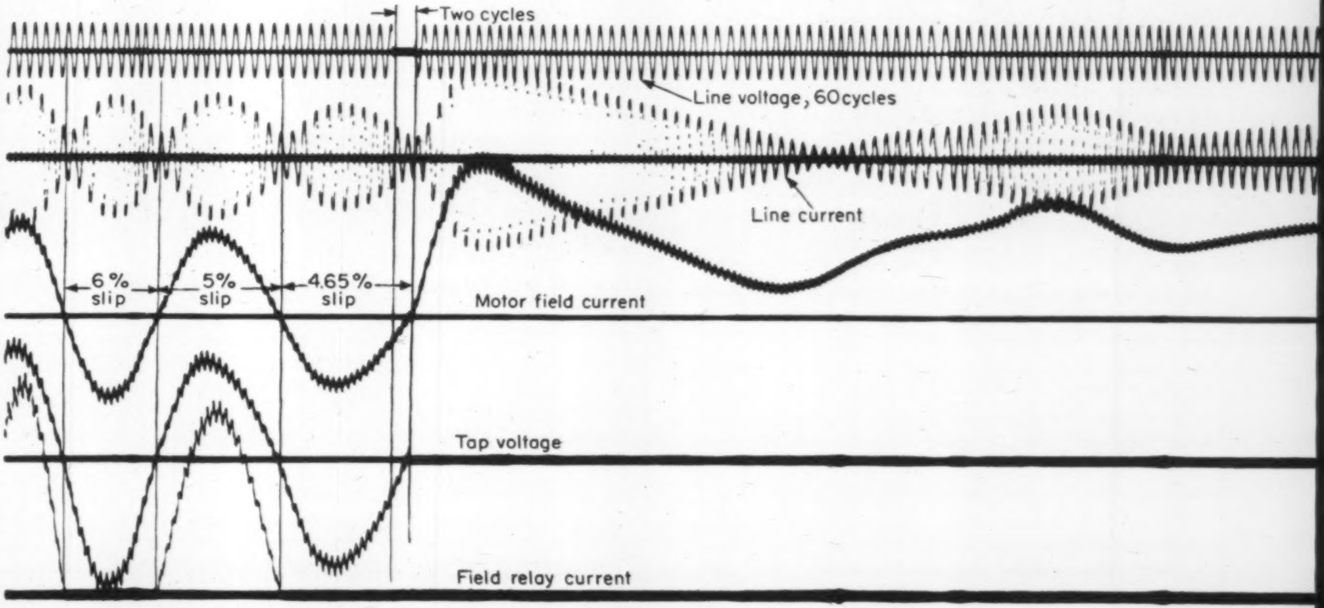

Key
FR-Field Relay
FRX-Field Relay Aux.
FC-Field Contactor
FCX-Field Cont. Aux.
M-Line Contactor
PFR-Power Factor Relay
PS-Oil Pressure Switch (if used)
OL-Stator Overload Relay
SCR-Sq.Cage Protective Relay
AC power lines
PM
L1
L2
L3
OL
C.T.
PFR
M
T1
T2
T3
Synchronous motor
FC
F1
F2
Shunt field
SCR
Discharge resistor
FR
Rect
Syn
To unloader
FCX
M
FRX
T.C.
C.C.
+
DC excitation lines
−
L1
L2
AC control source
Stop
Start
Exciter field forcing
FCX₁
PS
Oil
Resynchronizing jumpers
PFR
Resistor
T.O.

Fig. 7—Above—Connection diagram for a typical full-voltage synchronous motor starter. Control provides full motor protection while starting, accurate field application, and a dependable field removal system.

Fig. 8—Below—Oscillogram of voltages and currents in synchronous-motor line and field circuits at pull-in.



synchronizing is obtained by first polarizing the on-coming excitation and then accurately timing the closure of the field contactor so that the correct angle in the slip cycle is obtained.

In Fig. 8 is an oscillogram taken during an actual test with the field relay set to drop out at 5 per cent slip, but the motor is still accelerating. The top wave is a 60-cycle timing wave taken from the main ac power source. The break in this wave shows the drop-out point of the field-applying relay and the point of closure of the field contactor. The next wave shows motor stator current. Note the extreme modulation of this current due to the salient-pole effect. The fourth wave is the voltage tapped from the field discharge resistor which provides the signal used to measure rotor speed. The bottom wave shows the half-waves of the above voltage which is applied to the field relay. The third wave is the rotor field current. Note that the rotor is accelerating during succeeding half cycles from 6 per cent slip to 5 per cent to 4.65 per cent slip. The field relay was set to drop out at 4.75 cycles which it did very accurately. The field contactor was set to close within 2 cycles on the timing wave so that at the instant the induced current wave was passing through zero in a positive direction, the dc excitation circuit was closed to apply direct current to the rotor winding in this same direction. Note from drawing *i* in the operating characteristics discussion that optimum pull-in torque is obtained with an angle of approximately 30 deg. But also note that with this system, the field cannot be applied in the torque valley shown in drawing *i* since the relay will not drop out until the length of the blocked-out half cycle corresponds to the time setting of the relay. With an accelerating rotor (in which case a half cycle is longer than the time setting of the relay), the field will be applied earlier which puts the angle toward zero or even over to the right-hand end of the torque curve of drawing *i*. This results in a very small decrease in pull-in ability of the motor.

In addition, this system will check the availability of dc voltage sufficient for synchronizing before attempting to close the field contactor. This prevents operation of the motor with the field circuit open at any time.

For pull-out protection, a power-factor field-removal relay, Fig. 7, is used which is an accurate means of measuring the load angle of the rotor. When the angle between the axes of stator and rotor poles reaches the exact pull-out point, the field contactor is opened. The equipment is carefully co-ordinated with the motor characteristics in each case so that excitation will not be taken off prematurely, but when the load angle becomes such that pull-out actually has begun, field will be removed within the first half slip-cycle.

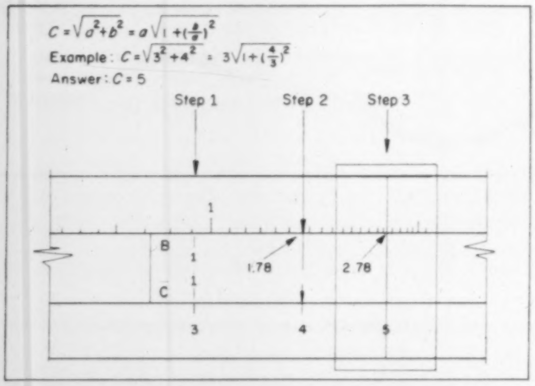
The squirrel-cage winding is protected by a thermal relay, Fig. 7, against stall and operation at subsynchronous speed.

Tips and Techniques

Sum of Squares on Slide Rule

Problems involving the sum of two squares can be handled readily on the slide rule. For problems such as $X = \sqrt{a^2 - b^2}$, it is only necessary to add 1 during the slide-rule calculation.

1. Bring index of C scale over *a* on D scale.


$C = \sqrt{a^2+b^2} = a\sqrt{1+(\frac{b}{a})^2}$
Example: $C = \sqrt{3^2+4^2} = 3\sqrt{1+(\frac{4}{3})^2}$
Answer: $C = 5$
Step 1
Step 2
Step 3
1
B
1
1.78
2.78
1
C
3
4
5

2. Bring hairline over *b* on D scale and read number under hairline on B scale.
3. Add 1 to this number and bring hairline to the sum on B scale. Read answer on D scale.

The method is based on

$$c = \sqrt{a^2 + b^2} = a\sqrt{1 + \left(\frac{b}{a}\right)^2}$$

—Rudolph Haller, *Engineering Development. Chemstrand Corp., Decatur, Ala.*

Construction Aid

It is sometimes necessary during the course of a drawing to establish points by construction lines that are not necessary on the final drawing. Erasing can be avoided by fastening a piece of tracing paper over the area and doing the constructions on it rather than on the drawing itself. The established points can be located by punching through with a pin.—Jesse Roth, *New York, N. Y.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, Machine Design, Penton Bldg., Cleveland 13, O.

The Personal Side of Engineering

By EDWIN C. NEVIS Personnel Research and Development Corp., Cleveland, Ohio

Professional Prestige

MANY engineers feel that they have lost status in recent years, are often treated more like workers than like professional people and, in general, are not afforded the respect warranted by their education, training, and contribution to the public welfare. In contrast, some others say that status of the engineer is better today than ever before, and that engineers have far more acceptance today as professionals. Such conflicting views indicate much confusion about the engineer's status.

To begin with, during the early years of this century, engineering was a new and exciting profession. Room existed for the independent practice of the profession, accompanied by the kind of status that goes with anything new, romantic, and adventurous. Now, however, growth of the giant corporation requiring, in some cases, thousands of engineers has resulted in a less independent and more commonplace role in the eyes of the general public.

Perhaps even more important has been the growth of the managerial class—individuals whose status derives from the fact that they supervise and direct the efforts of others. This is a potent factor in lessening the status of engineers and in attracting people out of the field. Management itself has enhanced this view by rewarding its management group in terms of status and monetary return significantly more than its engineering people.

Along with the emphasis upon good management as the key to industrial productivity, the status of engineers has suffered from the fact that we now appear to be in the midst of an "age of distribution" in which sales and distribution of products have become of great importance. One result is, of course, the great interest in sales work demonstrated by many engineers.

Along with the development of the age of distribution has come a strong emphasis upon good social relations. There is a tendency to overevaluate the more extroversive personality and to have a negative view of the more intellectual-minded person who is, truthfully or not, perceived as being in the scientific or engineering fields. Our society places great emphasis upon getting along with other people and less emphasis upon individual achievement and getting along with oneself—abilities which are most important for success in the scientific professions. Such "anti-intellectualism" has also lessened the status of the profession and discouraged young people from entering the field

One other factor which has undoubtedly influenced the status of the engineering profession has to do, paradoxically enough, with the great achievements of engineers. Most people quite readily admit that engineers can do "just about anything." However, there is a great deal of awe as to just how engineers go about doing things. This is quite similar to the medical profession, where advances in treatment have made the doctor's work look quite simple even though patients are at a loss to understand exactly how he brings about a "miraculous" cure.

Awe of what engineers and scientists do indicates a combination of respect for what can be done and some fear because of lack of knowledge. It may well be the status of engineering is fuzzy because the engineer's work is now far removed from what the public—and business people, too—can understand. If the engineer continues to be somewhat off by himself, communicating only within his profession and not making an effort to educate the public, then the status of the profession will probably continue to be somewhat vague, ambiguous, and not as high as it might otherwise be.

Unless young people are more aware of the challenge in engineering work, there is less liklihood of their following such a career than sales or general administration careers, which are played up romantically in the popular literature. In this respect, the engineer and the engineering societies might again ask themselves whether they are telling the general public, in terms that are understandable to all, about the group's contribution to the well-being of our society.

Beginnings in this direction have already been made in newspaper advertising and pamphlets put out by business organizations to play up the challenge and adventure in engineering. Much more appears to be needed on a grass-roots level. Engineers might take time and effort to communicate and to impress personally upon their neighbors, their relatives and acquaintances the value of what they are doing. By playing up the importance of their role, engineers can, in this not-so-indirect way, increase their status in the public eye and in the business community, and perhaps gain the accompanying rewards and privileges which they want so strongly to achieve.

Methods for determining

Transient Response of Servo

Part 2—Transient Response from Transfer Functions

By J. M. NIGHTINGALE
Manchester, England

DETERMINATION of transient response from knowledge of the steady-state harmonic response function $Y_c(j\omega)$ was discussed in the first part[17] of this two-part series. The input was broken down into sinusoidal components, and the system responds to each component according to the value of $Y_c(j\omega)$ at the particular frequency.

This second article deals with the determination of transient response mainly from knowledge of the more general function $Y_c(s)$, the steady-state response function for a complex frequency $s = \alpha + j\omega$.

If $\theta_i(t)$ can be expressed in terms of its complex frequency spectrum $\Theta_i(s)$ [mathematically $\Theta_i(s)$ is the Laplace transform of $\theta_i(t)$] then the output spectrum is given by

$$\Theta_o(s) = Y_c(s)\Theta_i(s) \tag{24}$$

Recovery of the output as a function of time is simplified if a physical linear system with constant parameters is being considered since, in this case, $Y_c(s)$ can be factored. Thus,

$$Y_c(s) = \frac{H(s - z_1)(s - z_2)\ldots(s - z_m)}{(s - p_1)(s - p_2)\ldots(s - p_n)} \tag{25}$$

The poles p_1, p_2, . . . determine the natural or "free-running" modes of the system. Generally the poles are complex so that the natural modes are damped sinusoidal time functions.

Unit-step function is most generally chosen as a representative input. In this case $\Theta_i(s) = 1/s$ (Reference 2). This relationship may be substituted into Equation 25 and the resulting expression expanded into a partial fraction. Thus

$$\Theta_o(s) = \frac{A}{s} + \frac{B_1}{s - p_1} + \frac{B_2}{s - p_2} + \ldots + \frac{B_n}{s - p_n} \tag{26}$$

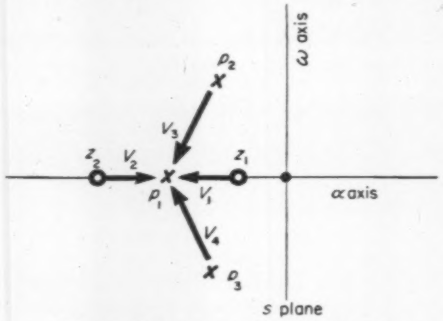


Fig. 9—Response coefficients can be obtained from diagram showing location of closed-loop poles and zeros.

From a table of inverse transforms,[2] it follows that

$$\theta_o(t) = Au(t) + (B_1 e^{p_1 t} + B_2 e^{p_2 t} + \ldots + B_n e^{p_n t})u(t) \tag{27}$$

The coefficients are given by

$$A = (-1)^{m-n}\left[\frac{z_1 \ldots z_m}{p_1 \ldots p_n}\right]$$

$$B_i = \left[(s - p_i)\frac{Y_c(s)}{s}\right]_{s=p_i}$$

Normally A is unity (for systems of order higher than one). Poles and zeros can be located on the complex s plane, Fig. 9. Then if all poles are distinct the coefficients can be found by vector mutiplication. Thus in Fig. 9, where $m = 2$ and $n = 3$, for example,

$$B_1 = \frac{\mathbf{V}_1\mathbf{V}_2}{\mathbf{V}_3\mathbf{V}_4} \tag{28}$$

Vectors $\mathbf{V}_1$, etc., represent complex numbers and must be manipulated accordingly.[2] In the case where more than one pole occurs at some point, such as a term of the form $(s - p_j)^2$ occurring

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[17] References are tabulated at end of article.

Systems

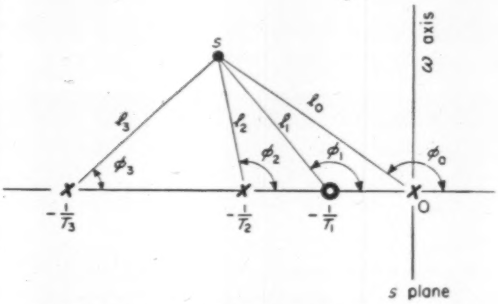

Fig. 10—Any point s on a root-locus must satisfy the gain and phase relations implied by the characteristic equation.

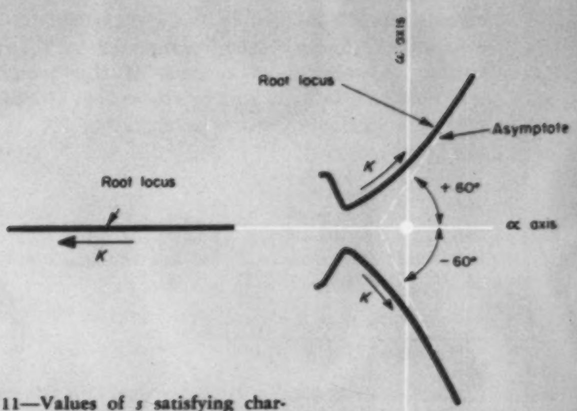

Fig. 11—Values of s satisfying characteristic equation trace out continuous curves in the s plane. These are called root loci. At each point K must be adjusted to satisfy magnitude condition. Hence, curves may be shown with K as parameter varying along the contour. Root loci can be drawn for variation of other parameters in $Y_o(s)$.

in denominator of $Y_s(s)$, the procedure is slightly different.[18]

Obviously the first step in determining response is to find the poles $p_1, \ldots$. These are the roots of the characteristic equation $1 + Y_o(s) = 0$. The difficulty is that this is usually something worse than a cubic in s and any direct approach to its solution will likely lead to considerable toil. However, ingenious methods have been derived to evade direct solution and the rest of this article is devoted to a brief summary of some of these. More detailed discussion is contained in the texts mentioned at the end of this article.

Most methods start with knowledge of the loop transfer function $Y_o(s)$. A typical example might be

$$Y_o(s) = \frac{K(1 + T_1 s)}{s(1 + T_2 s)(1 + T_3 s)} \tag{29}$$

The problem now is to relate the closed-loop poles to the open-loop poles and zeros, in this case 0, $-1/T_1$, $-1/T_2$, $-1/T_3$.

Root-Locus Method: Particularly useful, the root-locus method of Evans[19] traces out how the

Nomenclature

$A, B_1, \ldots$ = Constants
$A(t)$ = Response to unit-step function
a_0 = Ordinates of $\theta_0(t)$
$d_1, D_1, \ldots$ = Corrections to approximate closed-loop poles
$e_0, \ldots$ = Ordinates of $e(t)$
$h(t)$ = Open-loop response to unit impulse
$h_0, h_1, \ldots$ = Ordinates of $h(t)$
K = Scalar gain constant
k = Any integer 0, ±1, ±2, . . .
$l_1, \ldots$ = Lengths
m, m' = Number of closed-loop and loop zeros
n, n' = Number of closed-loop and loop poles
P, Q = Slope of gain and phase curves evaluated at closed-loop pole
$p_1, \ldots$ = Poles
R, θ = Polar co-ordinates of s
s = Complex frequency variable (Laplace operator)
$T_1, \ldots$ = Time constants
t = Time variable
$u(t)$ = Unit step function
$Y_o(s), Y_c(s)$ = Loop and overall transfer functions
z = Shift operator
$z_1, \ldots$ = Zeros
α, ω = Real and imaginary parts of s
$\Delta\alpha, \Delta\omega, \Delta X$ = Small finite increments
$\delta(t)$ = Unit-impulse function
β, γ, δ = Angles
ϵ = Small number
$\zeta = -\cos\theta$
$\Theta_i(s), \Theta_o(s), E(s)$ = Transformed input, output, and error
$\theta_i(t), \theta_o(t), e(t)$ = Input, output, and error
$\phi_1, \ldots$ = Angles
τ = Time interval

closed-loop poles move in the s plane as the gain constant K, or any other parameter in $Y_o(s)$, is varied. A very short account of this technique will now be given. It will be convenient to proceed with the example chosen in Equation 29. It follows that

$$Y_c(s) = \frac{K(1 + T_1 s)}{s(1 + T_2 s)(1 + T_3 s) + K(1 + T_1 s)} \tag{30}$$

Obviously the zeros of $Y_c(s)$ are the same as those of $Y_o(s)$, but the poles must satisfy:

$$\frac{K(1 + T_1 s)}{s(1 + T_2 s)(1 + T_3 s)} = -1 \tag{31}$$

Since s is in general a complex quantity, Equation 31 contains two conditions:

$$\frac{K\,|\,1 + T_1 s\,|}{|\,s\,|\,|\,1 + T_2 s\,|\,|1 + T_3 s\,|} = 1 \tag{32}$$

$$\arg\,(1 + T_1 s) - \arg s - \arg(1 + T_2 s) - \arg(1 + T_3 s) = 180 \text{ deg} + k\,360 \text{ deg} \tag{33}$$

where k is any integer, 0, ±1, ±2, . . .

For some point s satisfying these conditions, Fig. 10.

$$\left[\frac{KT_1}{T_2\,T_3}\right]\left[\frac{l_1}{l_0\,l_2\,l_3}\right] = 1 \tag{34}$$

$$\phi_1 - \phi_0 - \phi_2 - \phi_3 = 180 \text{ deg} + k\,360 \text{ deg} \tag{35}$$

Of these, the second is the one fundamental to the root-locus concept. If a value of s can be found to satisfy Equation 35, then the value of K in Equation 34 can be adjusted to satisfy Equation 34. It is found that values of s satisfying Equation 35 lie on curves in the s plane, Fig. 11. To each point on a curve there corresponds a value of K necessary to satisfy Equation 34.

The formal definition of a root-locus is a contour in the s plane so that if the value of s at any point on the contour is substituted in $Y_o(s)$, the argument of $Y_o(s)$ is 180 deg + k360 deg.

As described so far, each point on the locus corresponds to a particular value of K so that effectively root-loci tell how the closed-loop poles move when K is adjusted, other parameters being fixed. It is, however, possible to investigate changes in poles as other parameters are varied.[19]

Root-Loci Rules: Some simple rules for the construction of root-loci will now be given without rigorous justification. For the latter, one of the other references listed may be consulted.

1. Loci start on open-loop poles.

2. Loci terminate on open-loop zeros. Here the sense of traversing the loci is in the direction of increasing K. That is, rule 1 corresponds to $K = 0$, while rule 2 corresponds to $K = \infty$.

3. Loci appear in distinct segments. Number of segments equals the greater m' or n' (see Nomenclature).

4. Loci occur in conjugate pairs. That is, diagram is symmetrical about real axis, Fig. 11.

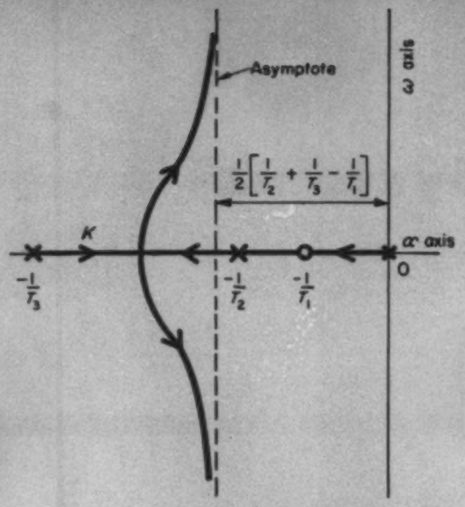
Asymptote
ω axis
$\frac{1}{2}\left[\frac{1}{T_2} + \frac{1}{T_3} - \frac{1}{T_1}\right]$
K
σ axis
$-\frac{1}{T_3}$
$-\frac{1}{T_2}$
$-\frac{1}{T_1}$
0

Fig. 12—Root locus for system of Equation 29, showing location of branches of locus, asymptotes, and break-away from real axis.

5. For large s, loop function $Y_o(s)$ behaves like C/s^q, where $q = n' - m'$, so that the asymptotes to the loci make angles $(180 + k360)/q$ deg with the positive real axis. In Fig. 111 the loci belong to a system having $q = 3$. For the system of Equation 29, for large s, $Y_o(s) \approx KT_1/T_2T_3s^2$ so that $q = 2$ and the asymptote angles are ±90 deg, Fig. 12.

6. Asymptotes do not radiate from the origin but intersect at a point on the real axis s_1 given by

$$s_1 = \frac{\Sigma \text{ open-loop poles } - \Sigma \text{ open-loop zeros}}{q} \tag{36}$$

Thus for the system of Equation 29, Fig. 12,

$$s_1 = \frac{1}{2}\left[\frac{1}{T_1} - \frac{1}{T_2} - \frac{1}{T_3}\right] \tag{37}$$

7. On real axis, loci lie only in sections to the left of an odd number of open-loop poles and zeros. This condition is also illustrated in Fig. 12 which shows the root-locus for the system of Equation 29.

8. Point of intersection of loci with imaginary axis can often be easily determined directly by substituting $s = j\omega$ in characteristic equation and solving directly. The corresponding value of K is simply determined by Routh's criterion.[3]

9. Angle at which locus leaves an open-loop pole is indicative—a point that can best be illustrated by an example. A system has loop poles at $s = p_1$, p_2, p_3, p_4 and a loop zero at $s = z_1$ as shown in Fig. 13. Suppose it is required to find the inclination γ of the locus leaving p_2. At point on locus near p_2 arguments of vectors from p_1, . . . , p_4, z_1 should add to give an angle of 180 deg + k360 deg provided contributions from zeros are added and contributions from poles are subtracted. Thus the inclination γ can be found from

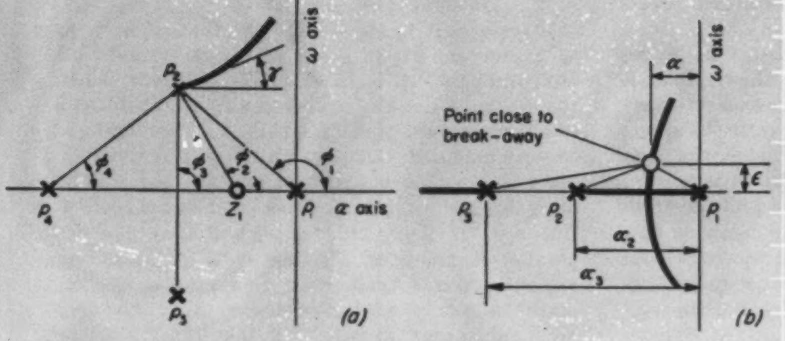

Fig. 13—At *a*, diagram illustrating determination of angle at which locus leaves an open-loop pole. At *b*, diagram illustrating determination of point at which branches of locus break away from real axis.

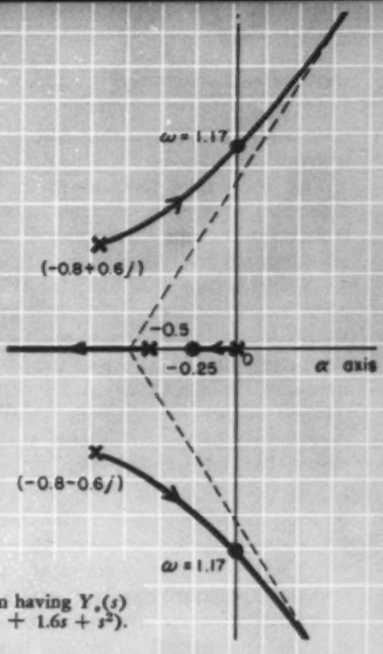

Fig. 14—Root locus for system having $Y_o(s) = K(1 + 4s)/s(1 + 2s)(1 + 1.6s + s^2)$.

$$\gamma + (\phi_2 - \phi_1 - \phi_3 - \phi_4) = 180 \text{ deg} + k\,360 \text{ deg} \quad (38)$$

Angles ϕ_1, ϕ_2, ϕ_3, ϕ_4, can be measured directly, being the arguments of vectors drawn to p_2 from the other poles and zeros.

An exactly similar argument can be used to find the angle at which loci enter open-loop zeros.

10. Where loci exist on segments of the real axis between two loop poles, the contour must split away in two branches from the real axis to satisfy rule 2, Fig. 14. If $-\alpha$ is the abscissa of the break-away point, then α can be estimated by considering a point on the branch very close to break-away with co-ordinates $(-\alpha, \varepsilon)$, ε being very small. Once again the sum-of-argument condition must be satisfied, and in this case all arguments can be expressed to first-order approximation as proportional to ε. Then ε can be cancelled from the equation, leaving an expression for α.

In the example shown in Fig. 14,

$$\frac{\varepsilon}{\alpha_2 - \alpha} + \frac{\varepsilon}{\alpha_3 - \alpha} + \left(\pi - \frac{\varepsilon}{\alpha} \right) = \pi$$

giving

$$\frac{1}{\alpha} = \frac{1}{\alpha_2 - \alpha} + \frac{1}{\alpha_3 - \alpha} \quad (39)$$

Equation 39 can conveniently be solved by trial-and-error methods.

Other rules exist, and are extensively treated in References 18 and 19.

Example: A simple example will illustrate the application of the above ten rules to the construction of root-loci. Consider

$$Y_o(s) = \frac{K(1 + 4s)}{s(1 + 2s)(1 + 1.6s + s^2)} \quad (40)$$

Loop poles are at 0, -0.5, $(-0.8 \pm 0.6j)$. Loop zero is at -0.25. Here $q = 3$ so that the asymptotes are equally spaced at 120 deg, Fig. 14. Equation 36 shows that the asymptotes meet at point -0.616, 0. The characteristic equation is

$$2s^4 + 4.2s^3 + 3.6s^2 + (1 + 4K)s + K = 0 \quad (41)$$

Putting $s = j\omega$ and separating real and imaginary parts lead to

$$\left.\begin{array}{l} 2\,\omega^4 - 3.6\,\omega^2 + K = 0 \\ 1 + 4K - 4.2\,\omega^2 = 0 \end{array}\right\} \quad (42)$$

Eliminating K and solving give $\omega = \pm 1.17$ as the points where the loci cut the ω axis.

The loci leave the complex poles at an angle of 35 deg (rule 9).

Now from rules 1, 2, 3, 4, and 7, it is possible to sketch the full locus as shown in Fig. 14. Despite the complexity of $Y_o(s)$, the procedure can be carried out in a very short time. It is advisable to check the accuracy of the sketched parts by checking that a few points on the locus satisfy the required conditions. Evans[19] has devised an instrument called a Spirule to simplify this task, and to help generally in the construction of the loci.

Phase-Angle Locus Method: Another approach to the task of loci construction is to map the s plane with lines of constant phase angles for each pole or zero in $Y_o(s)$. Points can then be found at which the total phase angle adds up to 180 deg + k360 deg. This method, called phase-angle locus method, is again quite easy to use.[20]

With the locus sketched it is now possible to indicate the variation of closed-loop poles with K. A simple way is to select a number of points on the locus, and then to apply the modulus condition—Equation 32, for example—adjusting K so that the two sides of the equation balance. Other quantities in the equation can be measured directly from the diagram.

The root-locus method is invaluable as a design tool. Previous articles have shown that it is necessary to restrict closed-loop poles to certain regions of the s plane. This restriction sets a limiting value of K and, for this value, the complete closed-loop pole-zero configuration is known. If this is so, it is an easy matter to find the transient response by the semigraphical methods outlined by Equations 25 to 28. Thus the root-locus method permits design with transient requirements in mind, a hitherto difficult task. Although only parameter adjustment has been discussed here, the method is particularly useful in that suitable modifying networks can also be specified to improve performance or stability, contrasting favorably with frequency-response methods in that transient response can be controlled directly. Space shortage prevents a more complete discussion on the use of root-loci in design, but more detail will be found in References 18-22.

Other Methods: To find the roots of the characteristic equation, it is necessary to find complex values $s = \alpha + j\omega$ which satisfy

$$Y_o(s) = -1 \qquad (43)$$

Nyquist's criterion shows that, if $s = j\omega$ satisfies Equation 43, for some particular value of ω, a plot of $W_o(j\omega)$ passes through $-1, 0$.

Therefore, it is to be expected that, if $\alpha + j\omega$ is a solution, a plot of $Y_o(\alpha + j\omega)$ would also pass through $-1, 0$. In Reference 3 it was shown that all points on the s plane could be transformed into corresponding points on the Y_o plane and use can be made of this fact to solve Equation 43. Since the method is approximate only, the s plane must be divided into a finite number of points. One way of doing this is with a grid of lines parallel to the axes, forming small squares, Fig. 15*a*. The transformation of this grid in the Y_o plane is also a grid of squares, although they are "curvilinear squares" in this case. Another way of saying this is that lines of constant α and constant ω intersect at 90 deg in the Y_o plane.

The small-square construction can now be used to map the grid on the Y_o plane. First, the locus of $Y_o(j\omega)$ (Nyquist plot) is drawn, divided by equal increments $\Delta\omega$ in frequency corresponding to vertical divisions of the s plane. Then squares can be drawn corresponding to the small squares produced in moving by distance $\Delta\alpha (= \Delta\omega)$ to the left in the s plane. Smoothing off the squares, Fig. 15*b*, gives an approximation to $Y_o(-\Delta\alpha + j\omega)$. The method can then be continued to obtain $Y_o(-2\Delta\alpha + j\omega)$, $Y_o(-3\Delta\alpha + j\omega)$, . . . and so on. Ultimately a value of α is found for which the curve passes through $-1, 0$ and the corresponding value of ω can be read off. Thus in Fig. 15*b*.

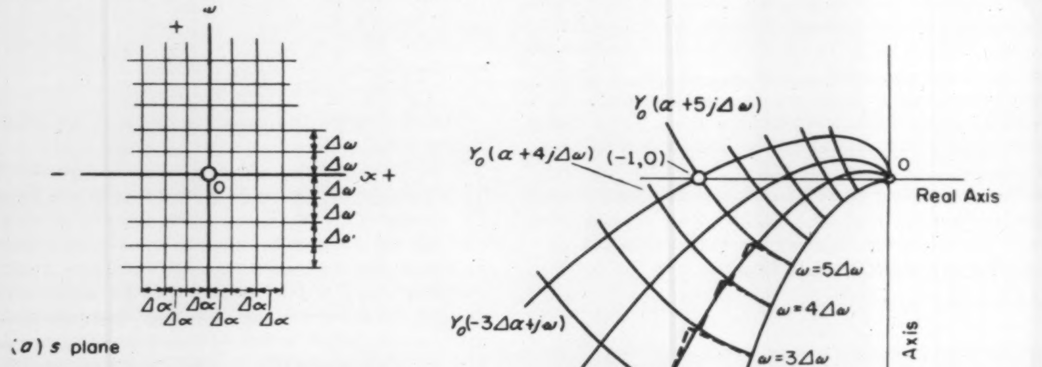

Fig. 15—At *a*, *s* plane divided into grid of small squares. At *b*, transformation of square grid into $Y_o(s)$ plane. Small square construction can be used to construct this mesh starting with $Y_o(j\omega)$ plot. At *c*, quantities which may be used to find the derivative of $Y_o(s)$, approximately, at point $-1, 0$.

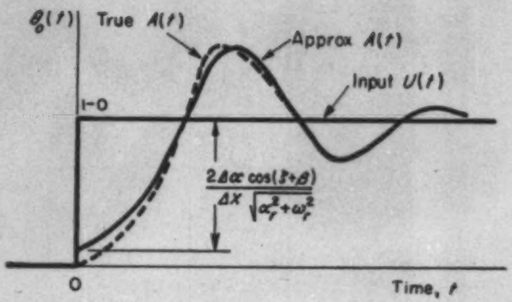

Fig. 16—Plot of approximate response obtained from dominant roots of characteristic equation. Often there is some error for small values of time, but the approximation gives accurate indication of overshoot and oscillation.

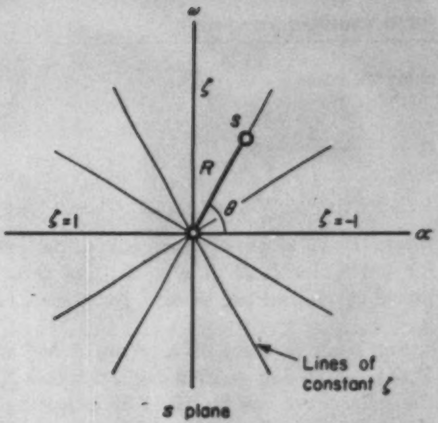

Fig. 17—The s plane divided by radial lines gives another approach to solution of characteristic equation.

$\alpha = -3\Delta\alpha = -3\Delta\omega$; $\omega = 5\Delta\omega$ gives one value of s satisfying characteristic Equation 43.

This method is often not successful for finding all the roots. However, in many practical systems it is found that one pair of complex roots, the most lightly damped, dominate the oscillatory part of the transient response.

If the roots are found by the method just discussed a simple artifice can be used to find the transient response. Suppose the root that has been found is $p_r = \alpha_r + j\omega_r$. Then there is a term in the transient response given by $B_r \, e^{p_r t}$. For unit-step input the coefficient is given by

$$B_r = \left[\frac{(s - p_r)\, Y_c(s)}{s} \right]_{s \to p_r} \tag{44}$$

Putting $s = p_r + \Delta s$,

$$B_r = \lim_{\Delta s \to 0} \left[\frac{\Delta s}{p_r} Y_c(p_r + \Delta s) \right]$$

$$= \lim_{\Delta s \to 0} \left[\frac{\Delta s}{p_r} \frac{Y_o(p_r + \Delta s)}{[1 + Y_o(p_r + \Delta s)]} \right]$$

Expanding $Y_o(p_r + \Delta s)$ about p_r, remembering that $Y_o(p_r) = -1$, gives finally

$$B_r = \frac{\dfrac{-1}{p_r}}{\left(\dfrac{d\,Y_o}{ds} \right)_{s=p_r}} \tag{45}$$

An approximation to the derivative in Equation 45 can be obtained by measurement from the plot of $Y_o(s)$, Fig. 15c:

$$\left(\frac{d\,Y_o}{ds} \right)_{s=p_r} \approx \frac{\Delta X}{\Delta\alpha e^{j\delta}} \tag{46}$$

Thus, for the component of response due to root p_r,

$$\frac{-\Delta\alpha}{\Delta X} \frac{e^{p_r t + j\delta}}{p_r}$$

The conjugate of this term must also be present in the response since $\alpha_r - j\omega_r$ is also a root. If the combined component of these roots dominates the response, there results, provided the system is at least of first order,

$$A(t) = u(t) \left\{ 1 - \frac{2\Delta\alpha}{\Delta X \sqrt{\alpha_r{}^2 + \omega_r{}^2}} e^{\alpha_r t} \times \cos(\omega_r t + \delta - \beta) \right\} \tag{47}$$

where $\beta = \tan^{-1}(\alpha_r/\omega_r)$.

A typical plot, Fig. 16, shows that in most cases there is some error for small values of t. The error is due to the absence of terms due to less important roots.

It is often profitable to divide the s plane by radial lines as shown in Fig. 17. The technique here is to plot the Y_o transformation corresponding to radial lines. Any point on a line is given by $s = Re^{j\theta}$, but Kusters and Moore[21] introduce notation

$$s = (-\zeta + j\sqrt{1 - \zeta^2})R \tag{48}$$

where $\zeta = -\cos\theta$. They also introduce the idea of plotting $Y_o(s)$ on a logarithmic basis, similar to logarithmic frequency-response curves.[14, 15] Reference 21 gives plots of magnitude and phase curves versus log R for given values of ζ for simple lag and quadratic lag terms. These may be added to give loop plots, for example, Fig. 18. For certain values of ζ, 0 db gain and -180 deg phase occur at the same value of R, such as ζ_o and R_o in Fig. 18, and these values substituted in Equation 48 give the roots of the characteristic equation.

From the gain and phase curves it is also possible to calculate the coefficient B_r of the component of response to unit-step input due to a root at $s = p_r$. Real roots occur for $\zeta = 1$ and, in this case, at $s = p_r$

$$B_r = \frac{20}{P} \tag{49}$$

where P = slope of gain curve, db per decade. For

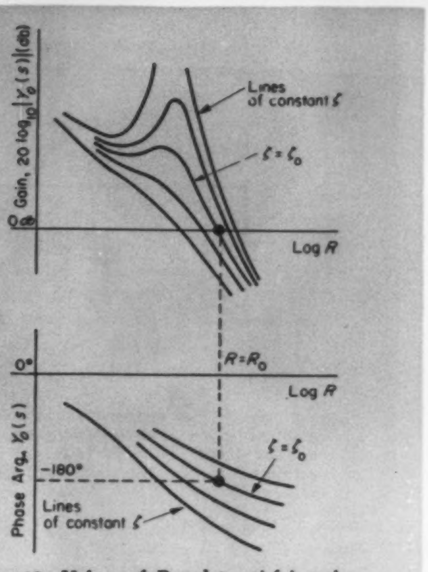

Fig. 18—Values of R and ζ satisfying characteristic equation must be such that gain is 0 db when phase is 180 deg + k360 deg.

complex roots

$$B_r = \frac{1}{\dfrac{P}{20} + j\dfrac{Q}{2.3}} \qquad (50)$$

where P = slope of gain curve, db per decade, for particular ζ, R at $s = p_r$, and Q = slope of phase curve, rad per decade, for same ζ, R at $s = p_r$.

For each R there is a given ζ for which arg $Y_o(s)$ = 180 deg + k360 deg. For these ζ, R values the gain curve can be lifted by adjusting K to cut the 0 db line. Thus the root-locus conditions have been satisfied. Since the given values of ζ, R define a curve in the s plane, satisfying these conditions, yet another way of constructing root-loci, with K as a parameter, is available.

Locating closed-loop poles by the method just outlined can be tedious since a wide range of values of ζ and R must be covered to locate all the poles. In order to reduce the amount of work it would be convenient to locate the poles approximately as a first step. Biernson[22] suggests a good approach to the task. First step is a crude approximation giving three locations for poles:

1. A pole at $s = -\omega_c$, where ω_c is frequency at which Bode gain plot, 20 $\log_{10}|Y_o(j\omega)|$, cuts the 0-db line.
2. Poles at $z_1, z_2, \ldots$ = zeros of $Y_o(s)$ for which $|z_1| < \omega_c$, $|z_2| < \omega_c, \ldots$.
3. Poles at $p_1, p_2, \ldots$ = poles of $Y_o(s)$ for which $|p_1| > \omega_c$, $|p_2| > \omega_c, \ldots$.

It is found that poles distant from $-\omega_c$ are quite accurate, but those nearer need refining. Next step is to make a correction to the rough estimates. For example, a better approximation to the closed-loop pole near the loop zero z_1 is taken to be $z_1 + d_1$. Then, to a first order, d_1 is given by

$$d_1 = \left[\frac{(s - z_1)}{Y_o(s)} \right]_{s \to z_1} \qquad (51)$$

A better approximation to the pole near open-loop pole p_1 is $p_1 + D_1$, where

$$D_1 = \Big[(s - p_1) Y_o(s) \Big]_{s \to p_1} \qquad (52)$$

Application of this method successively leads to rapid convergence toward true positions for distant poles, but for poles near $-\omega_c$ final adjustment must be made by the graphical method outlined in the last section. However, the advantage is that a good idea is obtained of where the poles will lie and the graphical plots can be localized.

A number of methods have been devised for determining closed-loop transient response from the transient response of the system with the loop opened. For example, if

$$Y_o(s) = \frac{K(1 + T_1 s)}{s(1 + T_2 s)(1 + T_3 s)} \qquad (53)$$

then the response of the system to unit impulse when the loop is opened, say $h(t)$, is the inverse Laplace transform of $Y_o(s)$ and can easily be determined since the location of the loop poles is known to be 0, $-1/T_2$, $-1/T_3$. Now the objective is to find closed-loop response when input is unit-step. It is convenient to find how the error $e(t)$ varies with time. In this case, the transformed error $E(s)$ is given by

$$[1 + Y_o(s)]E(s) = \Theta_i(s) \qquad (54)$$

Next step is to approximate $h(t)$, $e(t)$ and $\theta_i(t)$ as a sum of impulses, Fig. 19. Thus,

$$\begin{aligned} h(t) &\approx \tau[h_0\,\delta(t) + h_1\,\delta(t-\tau) + \\ &\qquad h_2\,\delta(t-2\tau) + \ldots] \\ e(t) &\approx \tau[e_0\,\delta(t) + e_1\,\delta(t-\tau) + \\ &\qquad e_2\,\delta(t-2\tau) + \ldots] \qquad (55) \\ \theta_i(t) = u(t) &\approx \tau[\delta(t) + \delta(t-\tau) + \\ &\qquad \delta(t-2\tau) + \ldots] \end{aligned}$$

Taking Laplace transforms of these three quantities,

$$\begin{aligned} Y_o(s) &= \tau[h_0 + h_1 z + h_2 z^2 + \ldots] \\ E(s) &= \tau[e_0 + e_1 z + e_2 z^2 + \ldots] \qquad (56) \\ \Theta_i(s) &= \tau[1 + z + z^2 + \ldots \qquad] \end{aligned}$$

where $z = e^{-s\tau}$ (Theorem 5, Reference 2). Substituting from Equation 56 in Equation 54 and collecting like terms in z,

$$\begin{aligned} &(1 + h_0)e_0 + [(1 + h_0)e_1 + h_1 e_0]\,z + \\ &\qquad [(1 + h_0)e_2 + h_1 e_1 + h_2 e_0]\,z^2 + \qquad (57) \\ &\qquad \ldots = 1 + z + z^2 + \ldots \end{aligned}$$

In this equation, $h_0, h_1, \ldots$ are known; $e_0, e_1, \ldots$ are unknown. By equating like powers of z it is possible to obtain expressions for the error coordinates, thus

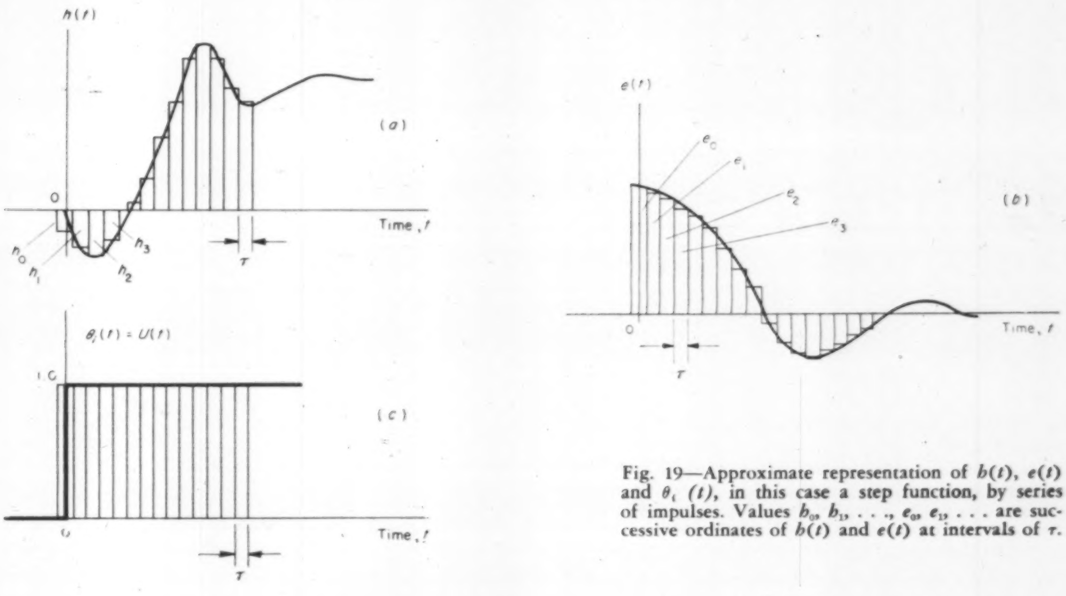

Fig. 19—Approximate representation of $h(t)$, $e(t)$ and $\theta_i(t)$, in this case a step function, by series of impulses. Values $h_0, h_1, \ldots, e_0, e_1, \ldots$ are successive ordinates of $h(t)$ and $e(t)$ at intervals of τ.

$$e_0 = \frac{1}{1 + h_0}$$

$$e_1 = \frac{1 + h_0 - h_1}{(1 + h_0)^2} \tag{58}$$

and so on

A smooth $e(t)$ curve can be sketched through the ordinates so calculated. Finally $\theta_o(t) = 1 - e(t)$ is obtained. The success of this method depends largely on selecting τ sufficiently small, about 1/20 of any oscillation period expected in the response.

A similar method is to attempt to express the transform of the output directly as a power series in z, thus

$$\theta_o(s) = \frac{Y_o(s)}{s[1 + Y_o(s)]}$$

$$= \tau(a_0 + a_1 z + a_2 z^2 + \ldots) \tag{59}$$

Transforming gives

$$\theta_o(t) = \tau[a_0\, \delta(t) + a_1\, \delta(t - \tau) +$$

$$a_2\, \delta(t - 2\tau) + \ldots] \tag{60}$$

Here $a_0, a_1, a_2, \ldots$ give output ordinates at times $t = 0, \tau, 2\tau, \ldots$. The difficulty lies in making the expansion, Equation 59. In the left-hand side s must be replaced by $1/\tau(\log z)$, but the result cannot be expanded as a power series in z. However, by replacing differentiation by difference of ordinates, it is possible to obtain suitable approximations. The simplest of these is

$$s = \frac{2}{\tau}\left(\frac{z - 1}{z + 1}\right) \tag{61}$$

Substituting Equation 61 for s in the left-hand side of Equation 59 permits a suitable expansion in powers of z. Effectively the system has been described by a linear-difference equation rather than by a differential equation.

REFERENCES

This article is the eighteenth in a co-ordinated group by J. M. Nightingale on servo systems. The previous articles and the issues of MACHINE DESIGN in which they appeared are:

1. "Automatic Control Systems" .... May 17, 1956
2. "Servo Mathematics" .... June 28, 1956
3. "Evaluating Servo System Performance—Part 1" July 26, 1956
4. "Evaluating Servo System Performance—Part 2" Aug. 9, 1956
5. "Analyzing Servo Systems" .... Nov. 1, 1956
6. "Hydraulic Servo Components—Part 1" .... Nov. 29, 1956
7. "Hydraulic Servo Components—Part 2" .... Dec. 13, 1956
8. "Hydraulic Servo Components—Part 3" .... Dec. 27, 1956
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REPRINTS

Articles listed above by J. M. Nightingale are available in three reprint volumes: Articles 1-5, Vol. 1 (32 pages); Articles 6-11, Vol. 2 (32 pages); Articles 12-17 plus this current article, Vol. 3 (44 pages). Volumes are available at $1.00 each from Reader Service Dept., MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

Modular Design of

Precision Gear Trains

for low-cost, built-to-order assemblies

By FRANK WILLIAM WOOD JR.
Design Engineer
Servonics Inc.
Alexandria, Va.

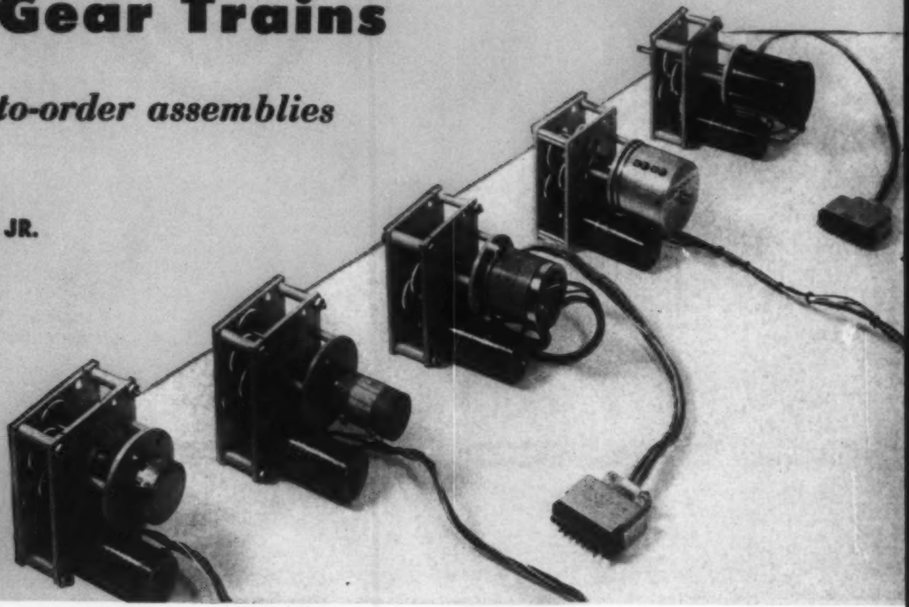


Fig. 1—Versatility of modular gear design is shown by this group of gear-train assemblies.

GEAR trains designed with modular gear units can give practically unlimited combinations of gear ratios and output components. Versatility of the design is especially noticeable in designing servo-mechanism gear trains because an almost endless number of assembly variations can be produced from a minimum number of standardized parts. Once the original design is worked out, there is very little engineering time needed to lay out assemblies for particular job requirements.

As an example, integrator gear-train units, Fig. 1, can be assembled with reduction ratios varying from a minimum of 100:1 to over 1,000,000:1. All have different output components (potentiometers, resolvers, etc.), yet all units use the same basic mounting plates and gears. The modular design shown was set up for use with a size-10

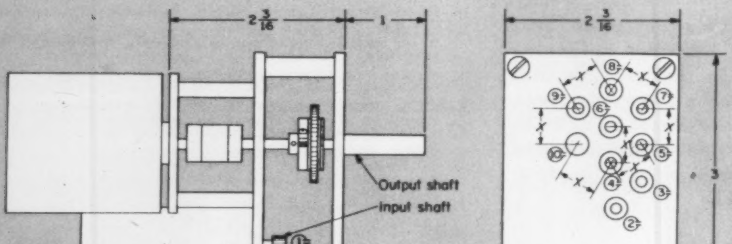


Fig. 2—Plate layout for modular gear train. Note that *X* dimensions are all equal, allowing multiple paths from motor to output component.

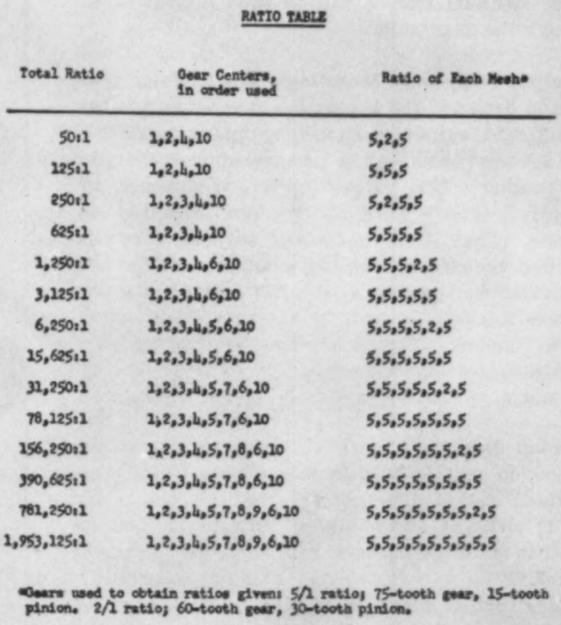
servomotor and an output component of 2-in. maximum diameter. The basic design principles are readily adapted for any motor and component size.

Design Objectives: The modular gear-train design was developed to satisfy five objectives:

1. Use of modular gear centers, i.e., all mating gears have the same total number of teeth and all gears have the same diametral pitch. In this case, it was decided to employ a total of 90 teeth and a diametral pitch of 96, with 15 teeth for the smallest pinion and 75 teeth for the largest gear.
2. Hexagonal layout for all gear centers. This arrangement allows several choices for the total number of meshes between motor and output component.
3. Minimum variety of gears and pinions, reducing the number of necessary pieces, and keeping cost at a minimum.
4. Pedestal-type mounting for the output component. Application of a wide variety of components is permitted by use of adaptor plates of various sizes and designs.
5. Incorporation of a slip clutch with adjustable torque setting. This objective was established by the necessity for use of output components with built-in limit stops.

Gear-Train Design: The plate layout, Fig. 2, is designed to permit extreme flexibility of ratios for the gear train. With the plate layout shown, the broad range of ratios listed in Fig. 3 can be provided with a minimum number of gears.

In the gear-train example shown in Fig. 4, 15-tooth pinion shafts are used throughout. There are three basic pinion shafts, each with the pinion located at a different position on the shaft. Thus,



RATIO TABLE

Total Ratio	Gear Centers, in order used	Ratio of Each Mesh*
50:1	1,2,4,10	5,2,5
125:1	1,2,4,10	5,5,5
250:1	1,2,3,4,10	5,2,5,5
625:1	1,2,3,4,10	5,5,5,5
1,250:1	1,2,3,4,6,10	5,5,5,2,5
3,125:1	1,2,3,4,6,10	5,5,5,5,5
6,250:1	1,2,3,4,5,6,10	5,5,5,5,2,5
15,625:1	1,2,3,4,5,6,10	5,5,5,5,5,5
31,250:1	1,2,3,4,5,7,6,10	5,5,5,5,5,2,5
78,125:1	1,2,3,4,5,7,6,10	5,5,5,5,5,5,5
156,250:1	1,2,3,4,5,7,8,6,10	5,5,5,5,5,5,2,5
390,625:1	1,2,3,4,5,7,8,6,10	5,5,5,5,5,5,5,5
781,250:1	1,2,3,4,5,7,8,9,6,10	5,5,5,5,5,5,5,2,5
1,953,125:1	1,2,3,4,5,7,8,9,6,10	5,5,5,5,5,5,5,5,5

*Gears used to obtain ratios given: 5/1 ratio; 75-tooth gear, 15-tooth pinion. 2/1 ratio; 60-tooth gear, 30-tooth pinion.

Fig. 3—Typical ratio table, showing range of ratios that can be achieved.

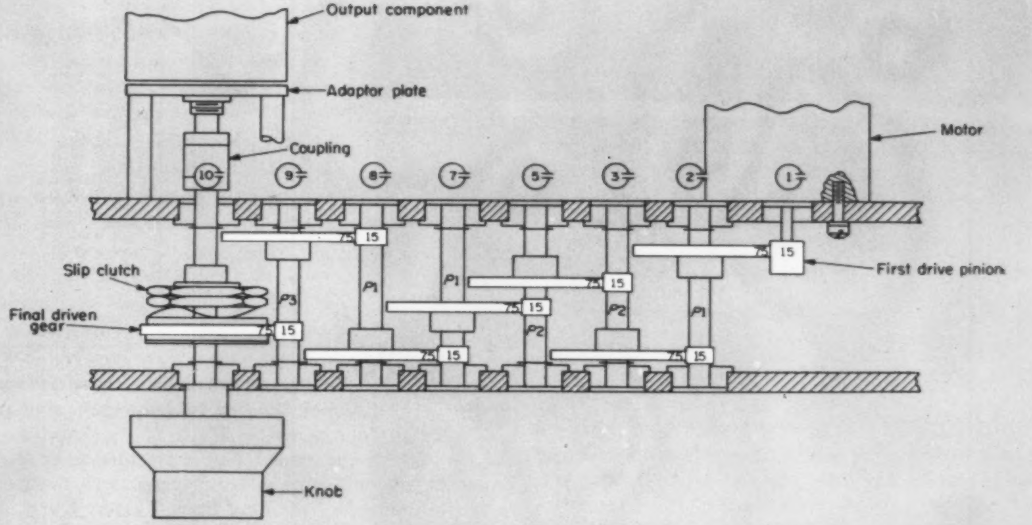


Fig. 4—Section through gear-train assembly, showing three positions of pinion on shaft.

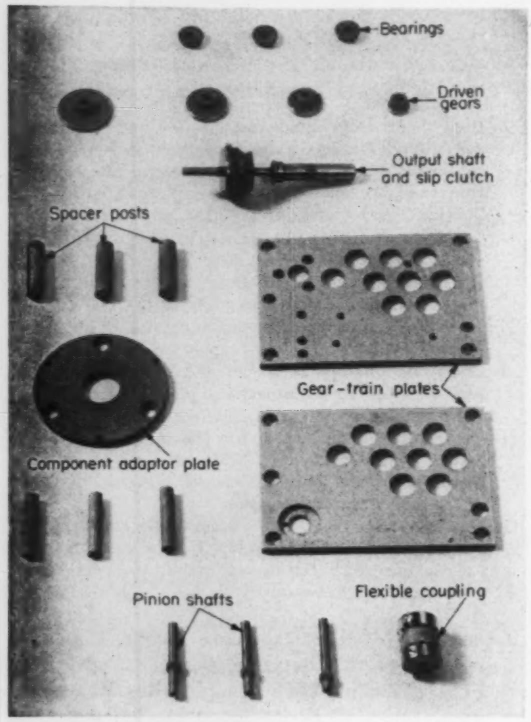


Fig. 5—Components are common to all gear trains, varying only in quantity and arrangement.

by staggering the mesh points between mating gears, identical pinions can be used several times through the gear train.

Output-Component Mounting: The modular gear train is designed for use with a maximum number of different output components; minimum alteration is required when one component is exchanged for another. This versatility is accomplished by use of a universal adaptor plate, mounted on spacers. Thus, it is necessary only to bore the required register hole in the adaptor plate for the particular component used. All components are coupled to the gear train by a zero-backlash, miniature coupling. The component coupling greatly facilitates zeroing and simplifies removal and replacement without disassembly of the gear train.

Detail Design: Overall size and weight of the assembled unit is held to a minimum. This compactness makes the modular unit attractive for use in airborne and shipboard equipment. Outline dimensions of a typical assembly are given in Fig. 2.

Construction detail is similar to that used by many manufacturers of gear heads, but has the added advantage of allowing mounting of various components directly on to the gear train. Due to the simplicity of assembly, Fig. 5, the modular gear train is very useful for breadboard or mockup use in the laboratory, where it may be used as an inexpensive and easily altered speed changer.

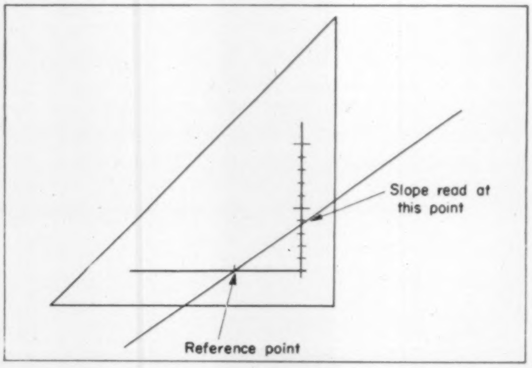
Tips and Techniques

Simplified Scaling

For drawings made to a scale of 4:1, advantages may be gained by using a metric scale. In this case, 100 mm = 1 in., 50 mm = ½ in., 12.5 mm = ⅛ in., etc. The scale is exactly 3.94:1 but is close to 4:1 for practical use, and has the advantage that all readings and measuring can be scaled in millimeters with the result in inches at a proportion of 4:1. For instance, 13.75 mm would be 1.375 in., 75 mm would be 0.750 in.—OTTO K. GRADE, *Springdale, Conn.*

Determining Slopes

An instrument for directly determining the slope of lines can be made easily from a drawing triangle. Two perpendicular lines are scribed near, and parallel to, the perpendicular edges of the triangle. A reference point is marked on one line (the base line) one inch from the intersection of the lines. The other line is calibrated in inches and decimal fractions. To use, the base of the triangle is placed parallel to the zero-slope axis and the reference point on the line whose slope is to be measured. The point at which the line cuts the calibrated scale gives the slope directly. Work of construction can be saved at the expense of convenience in use by cementing or taping a transparent rule to the triangle, instead of scribing lines.—JESSE ROTH, *New York, N. Y.*



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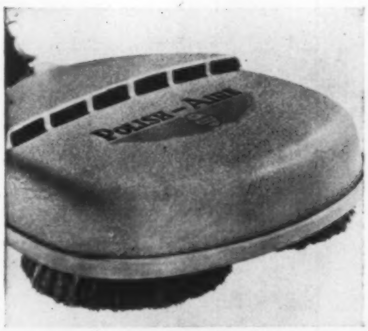
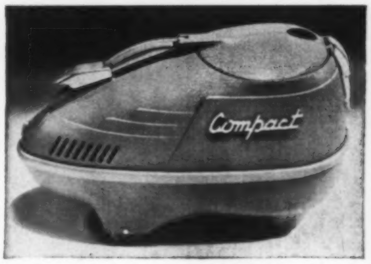
Air Turbine Drives Brushes in High-Speed Rotary Polisher

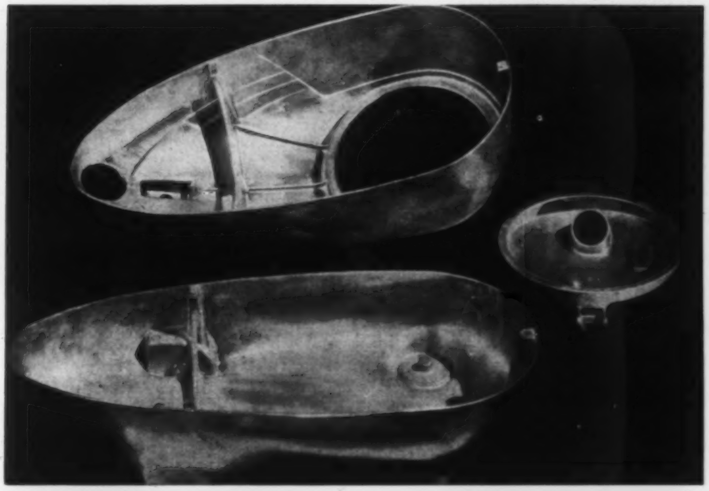


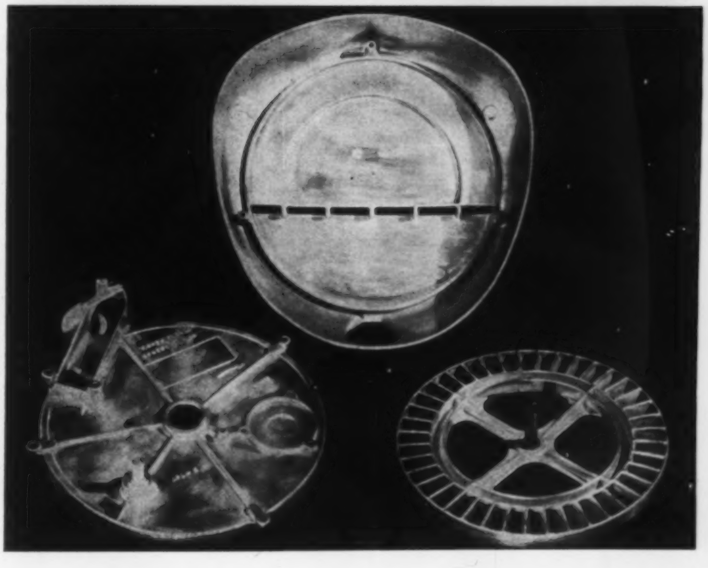


HIGH-SPEED ROTATING POWER for a new floor-polisher design is provided by an air-driven turbine. Air pressure to drive the turbine is supplied from a dual-outlet vacuum cleaner unit. One outlet produces vacuum and the other pressure. To propel the floor-polisher turbine, the operator transfers the flexible hose from the suction port on the vacuum cleaner unit to the pressure outlet, and the floor-polisher machine is then attached to the wands. Air expelled through the hose and over the turbo blades rotates the two floor-polisher brushes at a speed of 3500 rpm.

Both the Compact vacuum cleaning unit and the Polish-Aire floor polisher are produced by the Interstate Precision Products Corp., Anaheim, Calif.

Photos, courtesy of the American Die Casting Institute Inc.





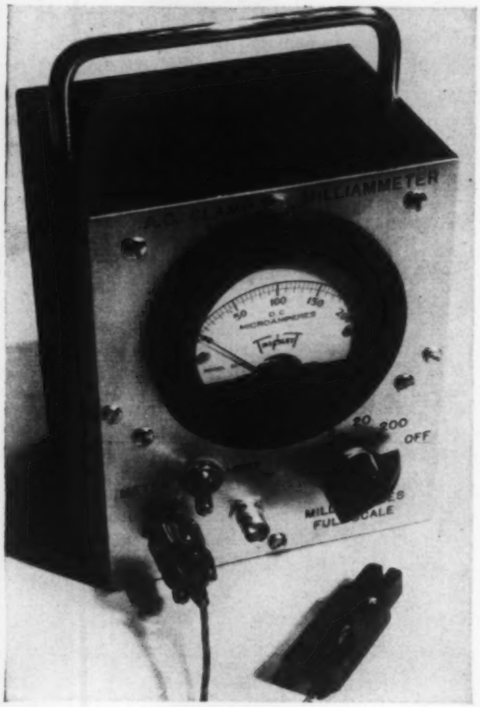
LIGHTWEIGHT CONSTRUCTION is made possible by the use of several aluminum die castings in design of both the cleaner and the polisher.

Eight air louvers in each side of the vacuum cleaner upper housing are pierced out after casting. The louvers could have been cored, but a slower casting cycle would have been required. Careful analysis of total costs revealed that mechanical piercing of the louvers was more economical. All sixteen openings are punched through simultaneously in a single operation.

In the floor polisher, the upper housing, chassis, and turbine are made of die-cast aluminum. Turbine blades are cast at a 15-deg angle, and a steel center post is cast as an insert in the turbine. The turbine is geared to the two brushes in the polisher assembly. Total weight of the polisher unit is 8 lb.

Transistorized AC Microammeter

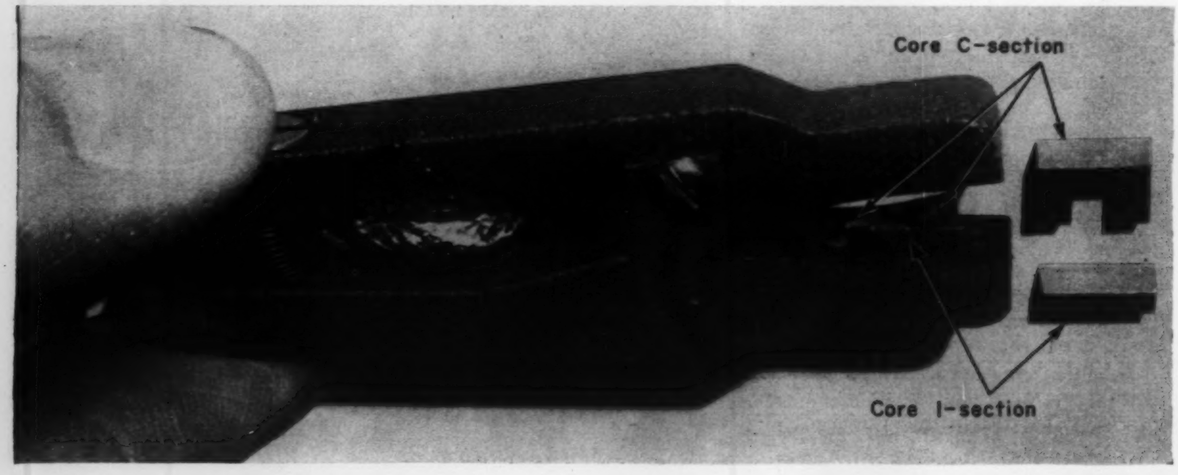
ACCURATE MEASURING of small currents at audio and radio frequencies, without breaking the circuit, is offered in a battery-powered, transistorized meter. Developed at the National Bureau of Standards by G. F. Montgomery and C. Stansbury, the electronic measuring instrument uses a split-core current transformer for a pickup probe.



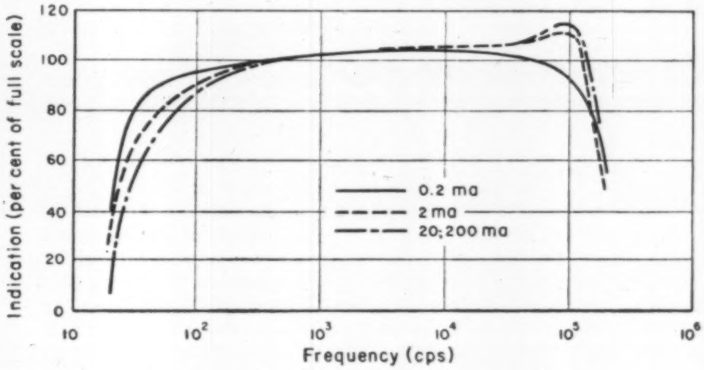
SPRING-LOADED CLAMP, in which the core is mounted, is made of Bakelite and is about the size and shape of an ordinary clothespin. The core of the transformer in the probe consists of 0.014-in. silicon-steel laminations. The core is formed of matching C and I-shaped sections. The completed core is 5/16 in. square, ⅛ in. thick, and contains a ⅛-in. window for the conductor under measurement.

A pin passes through the center of the I section, providing rotary movement in the plane of the jaws, so that the I-section will seat itself properly on the projecting legs of the C-section as the clamp closes. The matching faces of these parts are ground. Shielding with mu-metal minimizes sensitivity to external magnetic fields.

The C-section of the core contains two windings, each having 250 turns of No. 44 enameled wire. The four coil leads connect to a shielded four-wire cable and plug. One of the windings on the core is considered the secondary, and provides the actual current pickup. The other winding, the tertiary, is part of a feedback network to provide frequency equalization. By using this tertiary winding, transformer output for a particular primary current is very nearly linearized over the frequency range from 100 cps to 100 kc. The primary of the transformer is, of course, the conductor carrying the current to be measured.



Uses Clamp-Type Pickup Probe

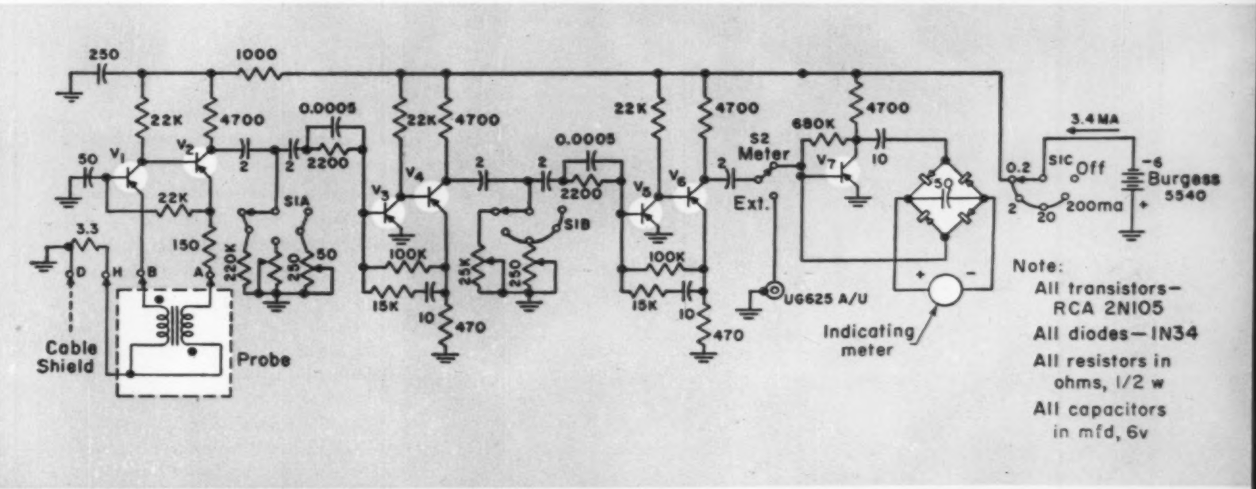


LOWEST SENSITIVITY RANGE of the prototype instrument is 200 mu amp full scale, and the highest 200 ma. Frequency range extends from 50 cps to 100 kc. In the experimental instrument, the high-frequency limit is imposed mainly by limitations of the transistors used, although even with high-frequency transistors the maximum operating frequency is probably not more than three or four times the transformer resonant frequency of 120 kc.

TRANSISTORIZED AMPLIFYING CIRCUIT is used to operate the indicating meter. Output of the transformer is fed into a preamplifier consisting of two transistors and a feedback network. Gain in this stage is sacrificed to provide frequency equalization and to reduce phase shift at the higher frequencies.

Gain is provided by two intermediate stages, each using a pair of transistors. Each stage uses direct coupling from the first transistor to the next. A feedback network, from the emitter of the second transistor to the base input of the first, stabilizes the dc operating point for each pair and reduces the overall current gain of each stage to about 20. The ac feedback factor at low frequency for each stage is about 100; the low-frequency current gain is thus stabilized against transistor and battery aging, and the frequency range for constant response is extended beyond that available without feedback.

The indicating meter, which has a 200-microamp dc movement, is driven through a full-wave rectifier. Although the input current from the intermediate amplifying stages is more than adequate to drive the movement to full scale, it is small compared to the normal operating characteristics of the rectifier. The rectifier, therefore, is operating in a nonlinear region. However, the nonlinearity is effectively reduced by a one-transistor amplifier whose gain is sacrificed to provide negative feedback through the rectifier. Linearity of response of the entire instrument is within the 2 per cent specification of the indicating meter itself, and shows that the degree of feedback in the meter network is adequate.

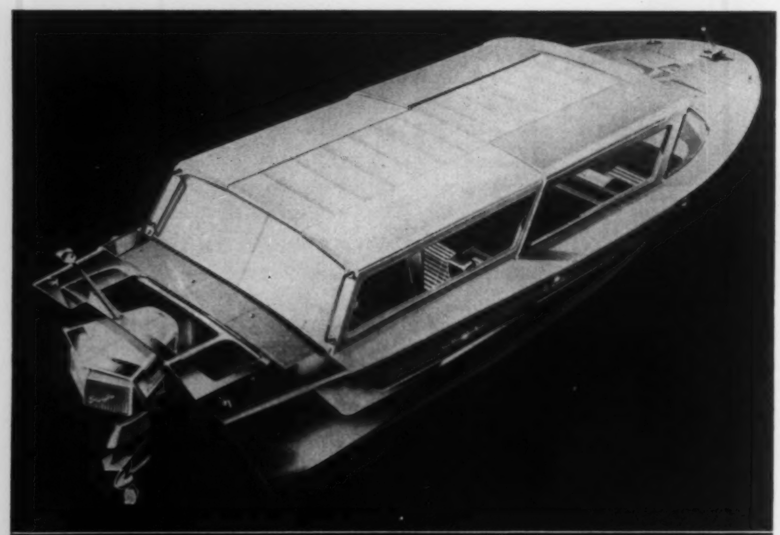

250
1000
22K
4700
0.0005
22K
4700
22K
4700
0.0005
680K
4700
3.4 MA
50
V_1
V_2
2
2
2200
V_3
V_4
2
2
2200
V_5
V_6
S2
Meter
2
V_7
10
50
0.2
S1C
Off
-6
Burgess
5540
22K
S1A
S1B
Ext.
2
20
200ma
+
3.3
150
220K
250
50
100K
25K
250
100K
D
H
B
A
15K
10
470
15K
10
470
UG625 A/U
Cable
Shield
Probe
Indicating
meter
+
-
Note:
All transistors—RCA 2N105
All diodes—IN34
All resistors in ohms, 1/2 w
All capacitors in mfd, 6v

"Station Wagon" Outboard Has Electrically Retractable Top

TELESCOPING CABIN TOP on the new Evinrude Starflite outboard permits easy conversion from a day cruiser to a utility-type runabout. Designed by Brooks Stevens for Evinrude Motors, the custom-built 21-footer has an electrically operated cabin housing which telescopes within itself on a track. Individual seats in the craft are also electrically operated so that they can be elevated and lowered at will through a 5-in. range of adjustment. Seats also convert into bunks when boat is used for overnight cruising.

The fiberglassed 21-footer is powered with an Evinrude four-cylinder 50-hp motor. An optional generator, driven by the motor, provides electric power for all lights and electrical installations aboard the craft.

The boat is equipped with recessed docking lights built into the bow. The 21-footer is instrumented with a tachometer, speedometer, ammeter, compass, compass light and a panel of buttons to control the horn, windshield wiper, canopy traverse, fuel gage, cigarette lighter, key switch, choke, control and docking lights. Interior lights are recessed beneath the seats to illuminate the companionway at night.



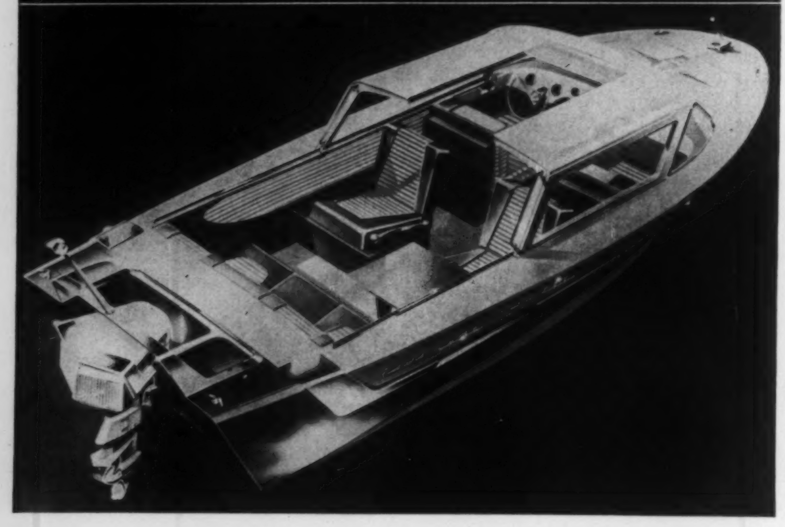
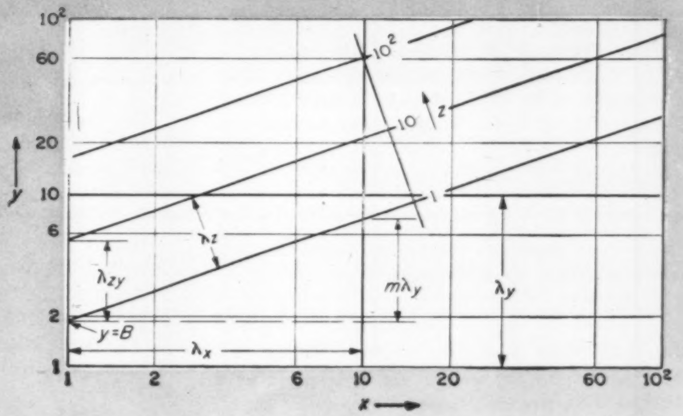


Fig. 1—Log-log plot of $y = Bx^m z^n$ for $m(+)$, $n(+)$, $m<1$, $n<1$. Relationships between scale moduli (measured lengths of x, y, and z cycles) are as follows:

λ_x = x-scale modulus
λ_y = y-scale modulus
λ_z = z-scale modulus
$= n\lambda_y/\sqrt{m^2(\lambda_y/\lambda_x)^2 + 1}$
λ_{zy} = projected length of z-scale modulus on y axis
$= n\lambda_y$



How to construct

NETWORK DIAGRAMS

. . . graphical devices that speed repetitive calculations

By WILL J. WORLEY
Assoc. Prof. of Theoretical and Applied Mechanics
University of Illinois, Urbana, Ill.

Nomographs and network diagrams have been called the stationary equivalents of a slide rule . . . with the added advantage that they allow addition and multiplication to be carried out at the same time. This article presents the fundamentals of such charts and illustrates typical uses in engineering analysis.

TECHNICAL articles and papers presenting new and useful alignment charts or network diagrams are published in a steady stream. Unfortunately, few such papers show how the charts were constructed. In fact, it is not uncommon for the alignment chart or network diagram to be presented without the equation from which it was developed and for which it provides a solution.

This article sets forth the fundamentals of the subject in a manner which permits the reader to construct his own nomographs, using commercially available graph papers, or constructing his own if desired. The type of nomograph treated here is generally known as a network diagram. However, the term nomograph will be used for convenience.

▶ Fundamentals

Two equation types which appear frequently in engineering analysis have the following forms:

$$y = Bx^m z^n \tag{1}$$

and

$$t = Bu^m v^n w^p \tag{2}$$

In these equations, B, m, n, and p are constants, x, y, z, t, u, v, and w are variables. By taking the log of both sides of Equations 1 and 2, they can be converted to forms suitable for solution by nomographs:

$$\log y = \log B + m \log x + n \log z \tag{3}$$

$$\log t = \log B + m \log u + n \log v + p \log w \tag{4}$$

When $z = 1$ in Equation 3, the last term is zero. The expression then takes the form

$$\log y = \log B + m \log x \tag{5}$$

Finding the Scale Modulus: Since Equation 5 is a linear function in log y and log x, it plots as a straight line with positive slope m on log-log paper, provided the log-scale modulus is the same on both co-ordinate axes. Scale modulus is the measured length of one cycle on the diagram.

If the scale moduli are not the same for the two co-ordinate axes, and are designated by λ_y and λ_x, the actual geometric slope, k, by inspection of Fig. 1 is seen to be

$$k = \frac{m\,\lambda_y}{\lambda x} \tag{6}$$

If $x = 1$ and $z = 1$, then $y = B$ from Equation 1. Thus the log-log plot of Equation 1 starts at $y = B$ when $x = z = 1$ as shown in Fig. 1. To determine variation with z, let x in Equation 3 equal unity. Thus

$$\log y = \log B + n \log z \tag{7}$$

Also let λ_z designate the length of the scale modulus in the z direction, and let λ_{zy} designate the length which one cycle in the z direction projects in the y direction. Then for $x = 1$,

$$\begin{aligned} \lambda_{zy} &= \lambda_y (\log y)_{z=10} - \lambda_y (\log y)_{z=1} \\ &= \lambda_y (\log B + n \log 10 - \log B - n \log 1) \\ &= n\,\lambda_y \end{aligned} \tag{8}$$

Making use of similar triangles in Fig. 1, one obtains

$$\begin{aligned} \frac{\lambda_z}{\lambda_{zy}} &= \frac{\lambda_x}{\sqrt{(m\lambda_y)^2 + \lambda_x^2}} \\ &= \frac{1}{\sqrt{m^2(\lambda_y/\lambda_x)^2 + 1}} \end{aligned} \tag{9}$$

From Equations 6, 8, and 9, the z-scale modulus is therefore

$$\lambda_z = \frac{n\lambda_y}{\sqrt{m^2\,r_{yx}^2 + 1}} \tag{10}$$

For most commercially available log-log paper, $\lambda_y = \lambda_x$ and thus $r_{yx} = \lambda_y/\lambda_x = 1$. Equation 10 then simplifies to the form

$$\lambda_z = \frac{n\lambda_y}{\sqrt{m^2 + 1}} \tag{11}$$

When exponents m and n in Equation 1 are positive, the nomograph appears as shown in Fig. 1. If m is negative and n is positive, lines representing z have a negative slope. If m and n are both negative, z lines have a negative slope and z increases in a downward sense as shown in Fig. 2.

▶ Three-Variable Equations

The method of extending the nomographic technique to problems of more than three variables

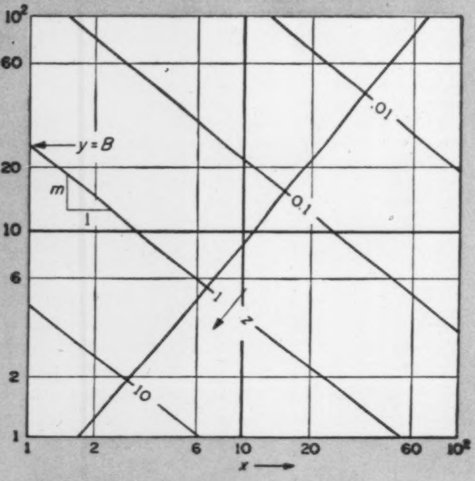


Fig. 2—Log-log plot of $y = Bx^m z^n$, for $m(-)$, $n(-)$, $m<1$, $n<1$.

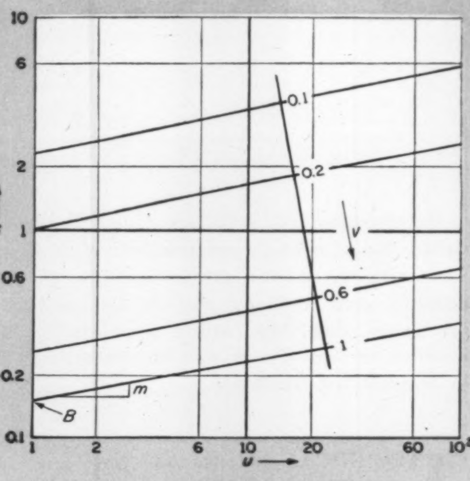


Fig. 3—Log-log plot of $s = Bu^m V^n$ for $m(+)$, $n(-)$, $m<1$, $n>1$.

will now be discussed. Consider Equation 2 and let

$$s = Bu^m v^n \tag{12}$$

or, combining Equations 2 and 12,

$$t = sw^p \tag{13}$$

Thus

$$s = tw^{-p} \tag{14}$$

Equations 1 and 12 are identical in form. Hence all preceding comments concerning Equation 1 apply to Equation 12. With suitable changes in subscript notation, Equations 6, 8, 9, 10, and 11 thus apply to Equation 12.

It is apparent that, having solved Equation 12 for s, one may apply Equation 14 in like manner to determine t. Equations 12 and 14 are solved in Fig. 3 and 4, while the composite diagram in Fig. 5—which is a superposition of Fig. 3 and 4—solves Equation 2 for the particular case $m = 0.2$, $n = -1.2$, and $p = 0.7$.

The process of solving successive three-variable equations and superimposing results can be extended to any number of variables, with results being presented on one nomograph. However, as the number of variables increases, the diagram becomes more difficult to read. For such problems, independent plots in juxtaposition provide an alternative.

If the variable u in Equation 2 is placed at the right of the log-log graph, the variable t may be placed on the left, with the intermediate variable, s, on the horizontal. This arrangement is frequently desirable. The procedure is carried out as described in the following section.

Example: Consider the equation giving the weight of solid, circular cross-section bar stock:

$$W = \rho V = 0.7854\, d^2\, l\rho \tag{15}$$

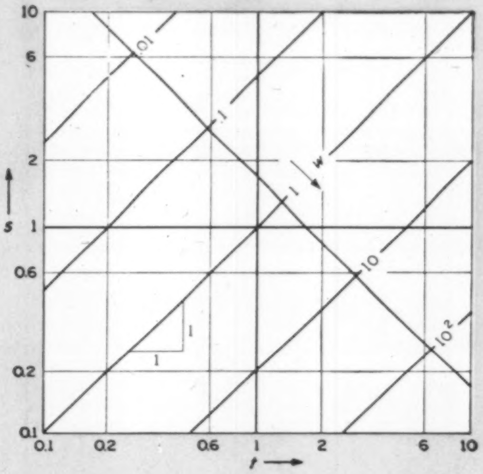


Fig. 4—Log-log plot of $s = tw^{-p}$ for $p<1$.

Here

$$V = 0.7854\, d^2\, l\text{, or } l = 1.273\, Vd^{-2} \tag{16}$$

In Equation 16, when $V = 1$ and $d = 1$, $l = 1.273$, and since V enters the equation to the first power, d lines have a slope of $+1$, Fig. 6. Recall that the negative power for d signifies a plus sense downward to the right for increasing values of d. The magnitude, 2, of the d exponent signifies two cycles on the vertical scale for each projection of a d-scale cycle on the vertical scale (Equation 8). From Equation 16, $l = 1.273$ for $V = 10^2$ and $d = 10$, giving point N on Fig. 6. Also, $l = 127.3$ for $V = 1$ and $d = 0.1$, establishing point M of Fig. 6. The l-scale appears on the right in Fig. 6.

By drawing a broken line from M to N, with ordinate intersections at $V = 2, 3, 4, \ldots, 70, 80, 90$, one may establish points for constructing the diagonal grid for the d scale. As before, the grid scale is completed by drawing lines with slope $+1$ through the intersections established by line MN. The equation $W = \rho V$ may then be plotted on Fig. 6 with constant-density lines having a slope of $+1$ and progressing upward to the left along the same axis as the d values.

Note that a plot of this type would require an overlapping log grid which can be confused with the grid for d. Ways of avoiding this problem are discussed in a subsequent section. For the present, however, a complete grid is not required, since the densities of only two materials, steel and aluminum alloy, are involved. Lines for these two values of ρ appear in Fig. 6, along with an illustration of the use of the plot for solving for bar weight with l, d, and the material specified. It is interesting to observe that the lower line on the diagram yields both volume and cross-sectional area for the bar, that is, $V = A$ for $l = 1$.

If one wanted the weights of solid cylindrical bars of materials with a range of densities, then a plot such as Fig. 7 might be more suitable. In this case, the right vertical axis is used for the d scale, while l appears on the diagonal scale. Ranges of l and d are such that the weights of flat discs may also be determined. The procedure used in the development of this nomograph is the same as for Fig. 6.

An advantage of this type of plot results from the difference in slopes of overlapping grids. The plot has the disadvantge of compressing the l scale 55 per cent and compressing the d scale 30 per cent. Grids for ρ scales are identical in Fig. 6 and 7. Density of water has been included to establish a reference for low-density materials.

Log-Log Plotting: It is occasionally necessary to plot a function such as $y = x^x$, which is linear if plotted with scales log(log y) vs. log(log x). For convenience, let log(log y) be designated by llog y. The llog scale may be obtained in a manner similar to that used to construct a log scale. In the present case, however, the log of the log of the number must be determined.

Suppose it is desired to construct two cycles of

Fig. 5—How to Construct a Three-Variable Nomograph

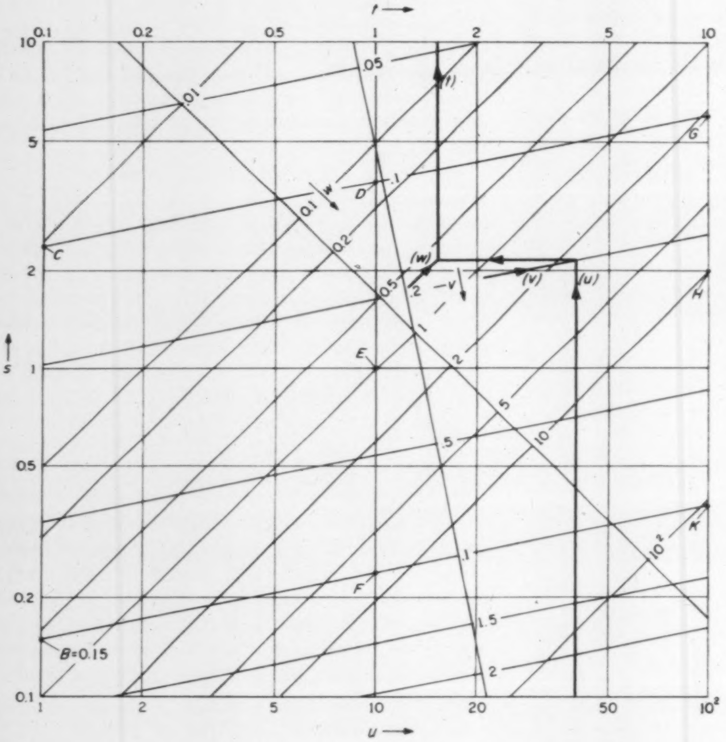
For an equation of the form $t = u^m v^n w^p$, assume that exponents have values $m = 0.2$, $n = -1.2$, and $p = 0.7$. Co-ordinates of designated intersections *B* through *K* are tabulated in Table 5.1.

Table 5.1

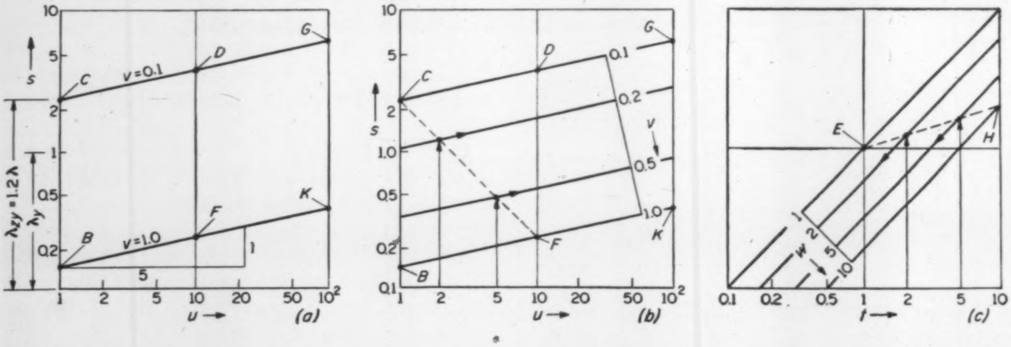
Intersection	Co-ordinates		
	u	*v*	*w*
B	1	1	
C	1	0.1	
D	10	0.1	
E	10		1
F	10	1	
G	10^2	0.1	
H	10^2		10
K	10^2	1	

Because *u* and *s* (Equation 12) axes have the same scale moduli (measured length of one cycle), $\lambda_s = \lambda_u$, and from Equation 6, geometric slope $k = m = 0.2$. Slope *m* of lines of constant *v* is therefore established by measuring 5 in. to the right from point *B* and then measuring up 1 in., sketch *a*. Line *BFK* ($v = 1.0$) is then drawn.

Point *C* is located by measuring up from *B* a distance equal to 1.2 times the measured length of one cycle on the vertical axis. This comes from the relationship expressed



Log-log plot of an equation of the form $t = u^m v^n w^p$ for $m(+)$, $n(-)$, $m<1$, $n>1$, $p<1$.


10
5
2
1
0.5
0.2
s
C
D
G
v=0.1
B
F
K
v=1.0
1
5
$\lambda_2 y = 1.2\lambda$
λy
1
2
5
10
20
50
10^2
u →
(a)
10
5
2
1.0
0.5
0.2
0.1
s
C
D
G
0.1
0.2
0.5
1.0
v
B
F
K
1
2
5
10
20
50
10^2
u →
(b)
E
H
1
w
2
5
10
0.1
0.2
0.5
1
2
5
10
t →
(c)

by Equation 8, where $\lambda_{ws} = n\,\lambda_s = 1.2\,\lambda_s$. Through point C, line CDG is drawn.

Spacing of grid lines in the v direction can be found without calculation by projecting the u-scale cycle divisions. Procedure is as follows: First connect points C and F as shown by the dashed construction line in sketch b. (Note that points C and F represent end points for one cycle on both u and v scales.) Ordinates from $u = 2$ and 5 divide line CF in a log-scale relationship. Projection of intersections of u ordinates and line CF to the v scale (drawn perpendicular to BFK) then establishes the v-scale grid spacing. A similar technique, making use of a construction line drawn through points D and K, establishes grid spacing for $v < 1.0$.

Grid spacing on the w axis is obtained by projecting t-scale cycle divisions, sketch c. Ordinates for $t = 2$ and 5 intersect the dashed construction line EH. As before, drawing lines parallel to $w = 1.0$ through these intersections yields the desired grid in the w direction. Note that w values increase downward to the right even though exponent p is positive. This apparent reversal of the usual pattern results from the substitution which required definition of s as an intermediate step.

a llog_{10} scale. Let the sçale extend over the range -1 to 0 to $+1$ for x, where $\text{llog}_{10}N = x$, and x represents the linear scale. Let the length of cycles -1 to 0 and 0 to $+1$ each be 10 in. The expression $\text{llog}_{10}N = x$ may be written

$$N = 10^a$$

where $a = 10^x$. If $x = 1$,

$$N = 10^{0.1} = 1.259$$

Likewise, if $x = 0$

$$N = 10$$

and if $x = +1$,

$$N = 10^{10}$$

Thus $N = 1.259$, 10, and 10^{10} on the llog N scale are placed opposite $x = -1$, 0, and $+1$ on the 20-in. linear scale.

Two intermediate values of N illustrate the method for constructing a complete scale. The numbers $N = 2$ and 20 are located as follows:

$$x = \log_{10} 2 = \log_{10} (\log_{10} 2) = \log_{10} (0.301)$$

$$= \log_{10} (3.01) - \log_{10} 10 = 0.4786 - 1.0$$

$$= -0.5214$$

$$x = \log_{10} 20 = \log_{10} (\log_{10} 20) = \log\, (1.301)$$

$$= 0.1143$$

Values of N representing powers of 10, such as 10^1, 10^2, . . . , 10^{10}, are spaced along the 10-in. cycle from 0 to $+1$ in exactly the same locations as 1, 2, . . . , 10 on a single 10-in. log cycle. Spacings in the subintervals are not the same on the llog scale as on the log scale. However, the major spacings, 10^2, 10^5, 10^7, etc., aid in the rapid construction of the llog scale in the range of x from 0 to $+1$. Spacings from -1 to 0 do not bear this fortunate relationship, since integral powers of 10 do not appear in this llog cycle.

The llog_{10} values may be obtained in two steps, either from llog slide rules with base 10, or from a table.

▶ Analytical Uses of Nomographs

Analysis of a physical phenomenon which behaves according to the equation

$$\sigma = B\varepsilon^m P^n \tag{17}$$

may be treated in almost the same manner as Equation 1. The difference between the two procedures results from the fact that, in Equation 1, values of B, m, and n are known. In Equation 19, one postulates that the phenomenon behaves in this manner. If a series of straight lines with constant and equal slope m is obtained, and if spacing for various values of P is logarithmic when the experimental data are plotted on log-log paper (σ on the ordinate and ε on the abscissa), then behavior of the data is in accordance with the proposed law.

If data were plotted on log-log paper with $\lambda_\sigma = \lambda_\varepsilon$, then $n = \lambda_{\varepsilon\sigma}/\lambda_\sigma$ from Equation 8. A full decade of the log cycle in the P direction is not required to establish the value of n, however. If the position of $\lambda_{\varepsilon\sigma}$ between 0.4 and 0.8 were available, and if this were divided by the portion of λ_σ between 0.4 and 0.8, or between 40 and 80 say, n could be evaluated.

Linearizing Functions: A function which plots as a curve on log-log paper may sometimes be linearized. Consider an equation of the form

$$(y - y_0) = Bx^m z^n \tag{18}$$

If Equation 18 were plotted as

$$y = Bx^m z^n + y_0 \tag{19}$$

it would appear as a series of curved lines on log-log paper. On the other hand, Equation 18 would plot like Fig. 1.

Consider $z = 1$ in Equation 18, where

$$(y - y_0) = Bx^m \tag{20}$$

This equation plots as a straight line, while

$$y = Bx^m + y_0 \tag{21}$$

is curved. A practical example is

$$\frac{P}{w} = Bf(\beta) \tag{22}$$

which plots as a concave upward curve on log-log paper. Upon correcting the data to

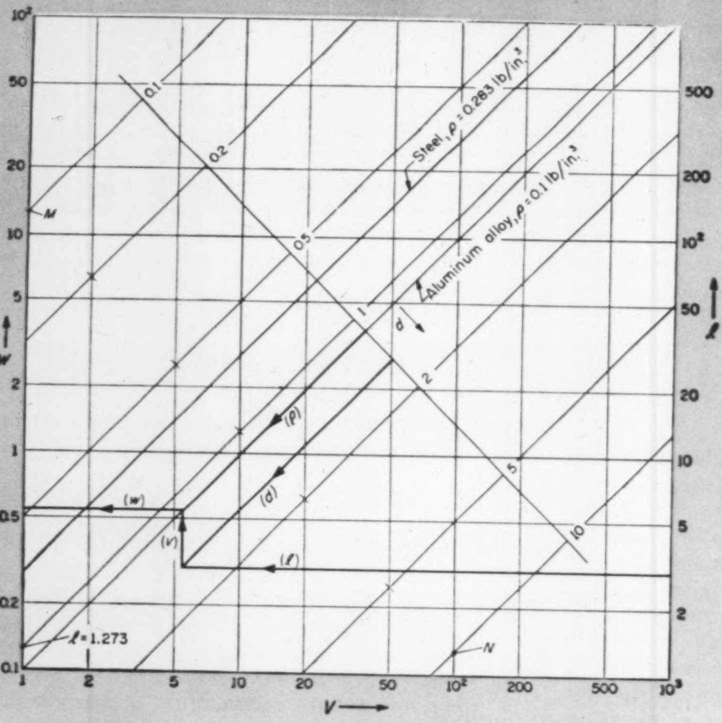


Fig. 6—Log-log plot of $W = \rho(0.7854\,d^2\,l)$.

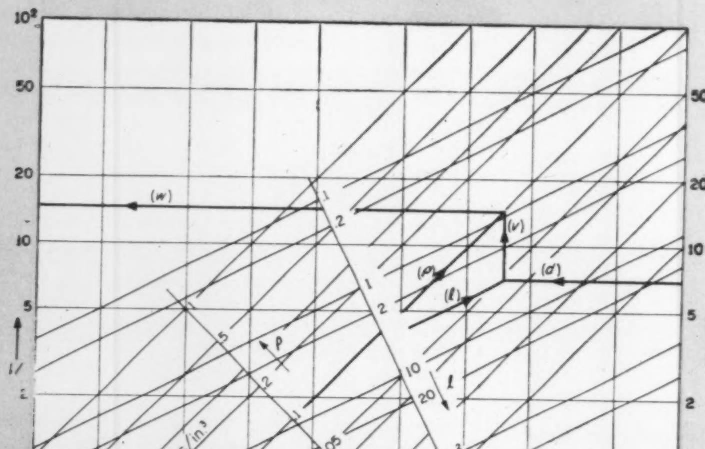


Fig. 7—Alternative log-log plot of $W = \rho(0.7854\,d^2\,l)$.

$$\left(\frac{P}{w}\right) - \left(\frac{P}{w}\right)_0 = \frac{P}{w} - 0.02 = 0.0715\,\beta^{-1.45} \qquad (23)$$

a straight line results on log-log paper. This line has a slope of -1.45, and when $\beta = 1$, it passes through the point $(P/w) - 0.02 = 0.0715$. A word of caution is needed here: Only those functions which behave in the manner of Equation 20 may be linearized by this procedure when plotted on log-log paper. Data which plot as an "S" curve for example cannot be linearized by adding (or subtracting) a constant to (or from) the ordinate or abscissa of the plotted data.

Deviation: Statistical analysis is occasionally simplified by noting that any measured length on a log scale yields the same per cent deviation independent of the magnitude of the plotted quantity. In terms of Fig. 1, this means that the per cent deviation between any two parallel lines, $z = a$ and $z = b$, is constant and independent of x.

A proof of the foregoing statement follows. Consider Equation 1 evaluated along any vertical line with $z = a$ and $z = b$. That is,

$$y_{x,a} = Bx^m a^n \qquad (24)$$

and

$$y_{x,b} = Bx^m b^n \qquad (25)$$

The per cent deviation in y is

$$\left(\frac{y_b - y_a}{y_a}\right) 100 = \left(\frac{y_b}{y_a} - 1\right) 100$$

$$= \left(\frac{Bx^m b^n}{Bx^m a^n} - 1\right) 100 = \left[\left(\frac{b}{a}\right)^n - 1\right] 100 \qquad \ldots (26)$$

Thus, per cent deviation is independent of x and depends only on the magnitudes of a, b, and n.

▶ Data Analysis with Nomographs

It is frequently desirable to use a network diagram as a help in analyzing experimental results. The experimental data may be plotted directly on the network diagram, thus adding to its versatility and usefulness. Two typical engineering problems are presented here.

The nomograph in Fig. 8 was developed by the author for predicting the compressive strength of concrete. The range of data of this nomograph was extended, and later the nomograph was published.[1] This example is of interest because it makes use of two equations

$$\delta = \frac{\pi(f_2 - f_1)}{f_0} \qquad (27)$$

and

$$E_D = 0.0116\, W f_0^2 \qquad (28)$$

The logarithmic decrement, δ and the dynamic modulus of elasticity, E_D are, in turn, related to the compressive strength, σ, of the concrete cylinders. The resonant frequency, f_o, and the frequency difference $(f_2 - f_1)$, which yields an amplification factor equal to $\sqrt{2}$ times the amplification at a frequency f_o, are related to δ by Equation 27. The dynamic modulus of elasticity is related to the weight of the cylinder, W, and to f_o as indicated in Equation 28. For a given E_D and δ there is a

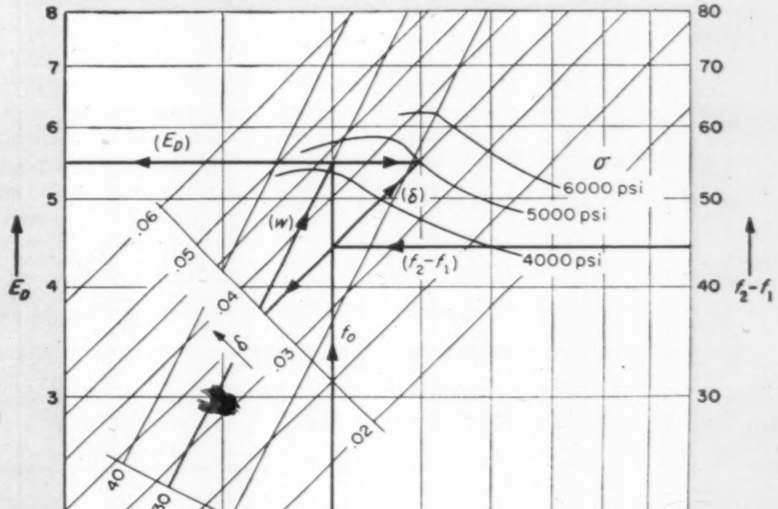


Fig. 8—Log-log plot for compressive strength of concrete.

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[1] References are tabulated at end of article.

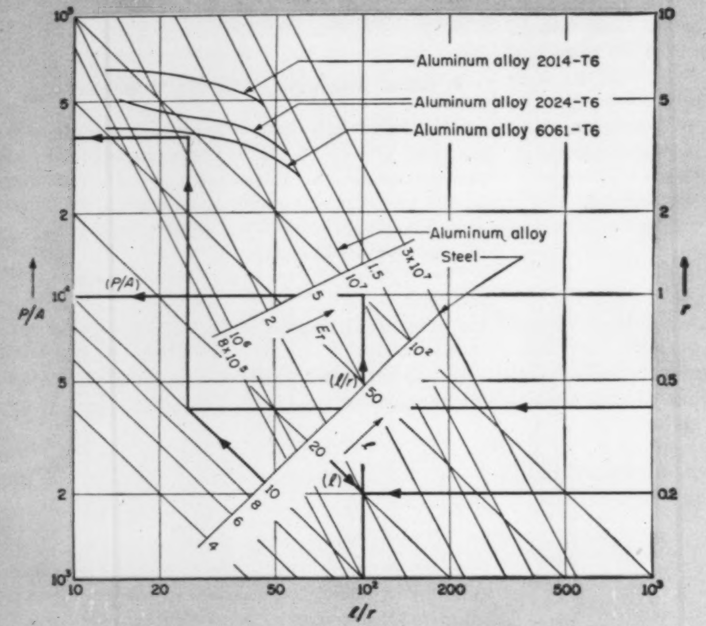

Fig. 9—Log-log plot of column equations.

corresponding σ which may be established by experiment. Once these values are known, the σ curves may be plotted at the appropriate intersections of E_D and δ. Thus, one need know only $(f_2 - f_1)$, f_o, and W for a new specimen in order to determine E_D, δ, and σ from the nomograph.

The nomograph in Fig. 9 was developed for use in solving both the Euler column equation

$$\frac{P}{A} = \frac{\pi^2 E}{(l/r)^2} \tag{29}$$

and the Engesser tangent-modulus column formula

$$\frac{P}{A} = \frac{\pi^2 E_T}{(l/r)^2} \tag{30}$$

In these equations (P/A) represents the column load per unit cross-sectional area, (l/r) is the slenderness ratio, E is the elastic modulus, and E_T is the tangent modulus. Both E and E_T must be determined by experiment. The plotted curved lines for the various aluminum alloys were obtained from Reference 2. As in the case of Fig. 8, the equation was solved in two parts: First, values of r and l were plotted to yield (l/r) on the horizontal axis. With (l/r) on the horizontal and (P/A) on the left-hand vertical axis, lines for various values of E or E_T were drawn. Finally, the data from Reference 2 were plotted at the appropriate intersection of the E_T and (P/A) lines. Two examples, one for a column of 6061-T6 aluminum alloy when loaded in the inelastic range and one for an aluminum-alloy column loaded in the elastic range, appear in Fig. 9.

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ACKNOWLEDGEMENT

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They Say . . .

"The patent system plays a far more vital part in the life of the small business that is actively using the opportunities for procuring patents afforded by the patent system. Many a small business is founded upon one or more patents. The patent system has in innumerable cases been the cause of the invention that led to the patent upon which the business was founded. Without the patent, many a small business would have been hopelessly and fatally outrun by its larger and more prosperous competitors."—C. W. OOMS, *patent counsel, La Salle Steel Co., Hammond, Ind.*

Design of
Thin-Wall Plastic Parts

Thin-walled parts produced by either vacuum forming or injection molding yield economies through material savings without sacrificing utility of the part

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THIN-WALLED plastic parts can be produced by injection molding and sheet forming techniques. Development of these techniques is responsible for the concept of thin-wall design, which minimizes the amount of material used yet maintains required properties. An oversimplified approach involves reducing the cross-section of a part in uniform increments. While this approach is adequate at times, it does not insure performance strength nor indicate cost reduction from material saving. Design practices for thin-wall molding are shown in Fig. 1.

Thin-wall molding and forming are means of preparing parts in which weight is not the determining factor, but rather area is the predominant characteristic. Such parts have a large area-to-weight ratio. These ratios are simply relative and are indicative of the character of the part. They compare the structure, area-wise, with another of different construction. For example, an injection-molded container weighing 1 oz, and having a surface area of 42.75 sq in., has an area-to-weight ratio of 42.75. A vacuum-formed refrigerator door-liner which weighs 80.6 oz and has a surface area

Fig. 1—Above—TV bezel illustrating use of reinforcing ribs. Rib thickness is less than the thickness of the wall supported to eliminate tendency toward sink marks on the wall side. Elongated holes are molded through cores in the mold.

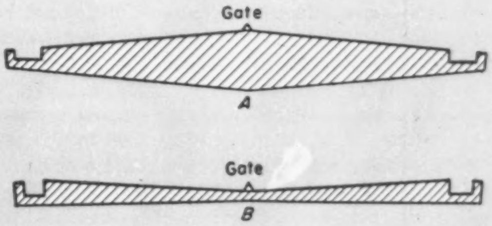


Fig. 2—Cross-section of die for refrigerator door-liner (exaggerated). Original design, top, caused increase in weight of the liner due to injection pressure forcing the die open. Redesign, bottom, allowed cooler material to flow with less resistance to far reaches of the mold cavity.

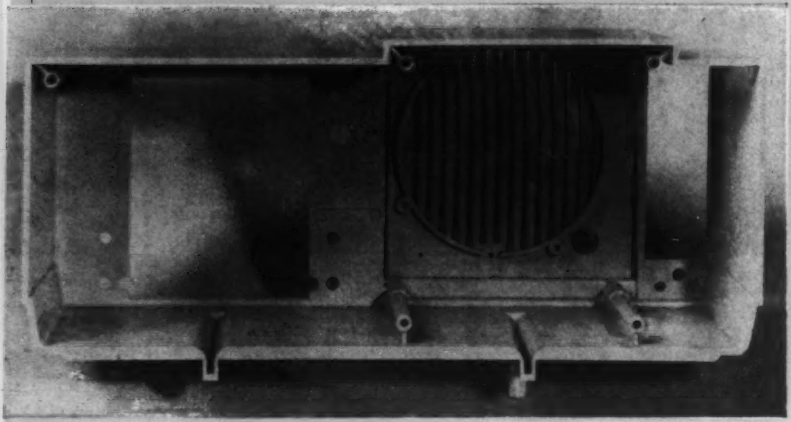


Fig. 3—Rear of molded radio cabinet. Note thickness of wall section around cored holes, and boss width at least equal to the hole diameter. Thickness of supports for the cored holes is less than the thickness of the wall to which supports are attached. The latter design consideration prevents formation of sink marks in the wall.

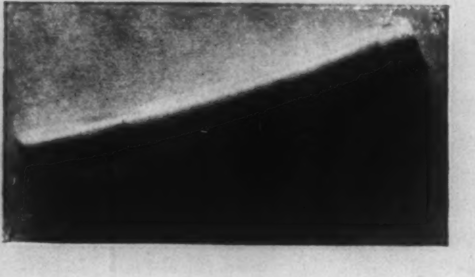


Fig. 4—Below—Improper coring of knife handle. Sink mark in handle was caused by difference in section thickness. The thick wall at the tip of the handle did not set up as fast as the thinner wall around the insert. Coring the handle to within ½ in. of the bottom minimized this tendency.

of 1152 sq in., has an area-to-weight ratio of 14.3.

Another example of high area-to-weight ratio is a molded styrene cup 0.037 in. thick, weighing ¼ oz and having an area of 26.95 sq in. The ratio here is 108. In contrast to these products having relatively high area-to-weight ratios, is a military brush back weighing 3.57 oz and having an area of 11.58 sq in. The ratio is only 3.25.

The term "thin wall" is popularly applied to lightweight, disposable items such as food containers. However, thickness of wall section cannot be accepted as a criterion of definition. The refrigerator inner-door liner has a thickness of 0.080 in. and is considered thin-walled compared to the 0.150-in. liner of several years ago made from laminated phenolic paperboard. The same 0.080-in. thickness, however, is not considered "thin wall" for the disposable plastic cup.

Laminated Sheet: Inner-door liners for refrigerators were made by impregnating sheets of paper with phenolic resin and laminating them under heat and pressure. The result was a lightweight, tough industrial part approximately 0.100 in. thick. As new refrigerators were designed with more complex compartmented door liners, the phenolic laminate became unsatisfactory because it could not be formed into necessary draws, and required painting to produce an adequate finish.

Molded Parts: Availability of high-impact styrene sped development of large capacity (300 to 400 oz) injection molding machines. Liners could now be injection molded with undercuts, lugs, and holes which made them ready for assembly into the finished door. These large injection molding machines were designed to produce parts as large as 2 by 4 ft which weigh as much as 7 to 8 lb. Production cycles range from 1½ to 2 min. Injection molds for these doors cost approximately $20,000 to $30,000. They are precision molds made to last through continuous production of a great number of parts, but are adaptable to minor model changes as required from time to time.

The thin-wall design of the door liner involves much of interest to those seeking high-quality injection molding. Design of the original door required the liner to be of constant wall thickness along the cross-section of the entire piece, or only slightly thicker in the center than at the ends. During injection, a tremendous pressure is required to fill the mold cavity and tends to open the die slightly to enable the plastic to flow to all parts. It was found that the mold opened as much as 0.010 in. which resulted in a weight increase of 5 to 8 oz greater than the expected 5 to 7 lb. To correct this situation, attention turned immediately to die design.

Tendency toward expansion of the die during flow of material to the far reaches of the cavity was minimized by making the center section of the die thinner than the far section, Fig. 2. Since Hot material is injected at the center, it was reasoned that cooler material would then flow with less resistance. When the mold was redesigned, no increase in part weight was experienced. A better part with less stress was produced without additional cost of extra material.

Thin-Wall Strength: As the wall section of a thermoplastic part is made thinner, its impact strength, or sharp blow resistance, decreases. This is primarily due to the phenomenon of orientation which occurs during flow of material into the cavity when the molecules tend to align themselves in one direction. This is particularly noticeable in thin walls, where more pressure is required to force the material into the wall section. Because relatively cool mold surfaces are required to set up the fluid plastic to a rigid phase, the plastic material on the outer edges of the cavity cools first. Thus, for thin pieces, tremendous pressure is required to force material into the cavity before setup occurs, and molecules tend to be unidirectional, or oriented.

In the direction of flow, or direction of molecular alignment, strength is much less than that at 90 degrees to flow. Thin-wall cups for example, will crack in this direction if too highly stressed. No empirical formula is available to determine this wall-thickness to strength ratio, but designers should be aware of it when changing wall thickness in a part.

Design of Molded Parts: By proper designing for thin-wall molding, structural members, ribs, and holes may be designed into the piece. Thickness of ribs should be less than that of the preceding wall section. Rib height should not be more than one-half the height of the wall section to prevent shrinkage and sink marks, Fig. 1. Sometimes, however, special design considerations eliminate sink marks if a higher rib is used.

For coring of holes, diameter of lugs should be approximately 1½ to 2 times that of the hole which is cored, Fig. 3. This minimizes danger of cracking when the screw or plug is inserted during assembly. Improper coring of parts produces a thick section which takes longer to set up than a thin wall, Fig. 4. Minimum radii for fillets on corners should be between 1/16 and 1/8 in., Fig. 5. Sharp corners concentrate stresses, and cracking is more apt to occur. Filleting parts allows less stress concentration and produces a better part as far as strength and moldability are concerned.

Some rule-of-thumb materials selection and wall-section thickness recommendations can be stated for design consideration. However, only experience and end use will prove whether or not these suggestions are satisfactory for specific applications.

Styrene, polyethylene, and vinyl plastics have become permanent materials in the production of thin-walled parts because they lend themselves to the processing of undercuts and deeper draws. Styrene, within the last few years, has been modified by addition of rubber which gives it greater strength and makes it suitable for deeper draws.

In general, for injection molding of industrial parts, rubber-modified styrene should be used in all wall sections where parts serve as structural and functional components. General-purpose styrene is satisfactory for decorative parts where abuse resistance is not important.

For injection molding of packaging containers with wall thicknesses above 0.040 in., general-purpose styrene is satisfactory. Medium-impact styrene is recommended for wall thicknesses between 0.030 and 0.040 in., and high-impact styrene for wall thicknesses below 0.030 in.

For sheet forming of industrial parts in which wall sections are generally 15 to 20 per cent thinner than comparable molded parts, and for packaging containers with wall sections generally 10 to 15 per

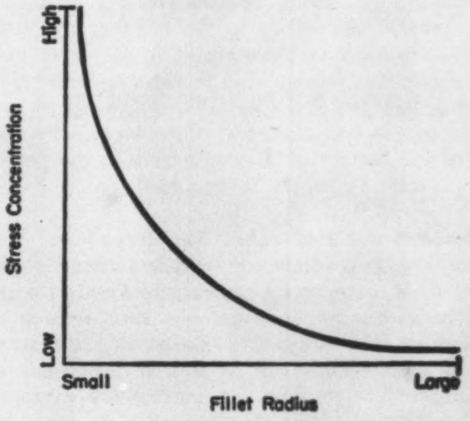


Fig. 5—Effect of fillet radius on stress concentration of filleted corner

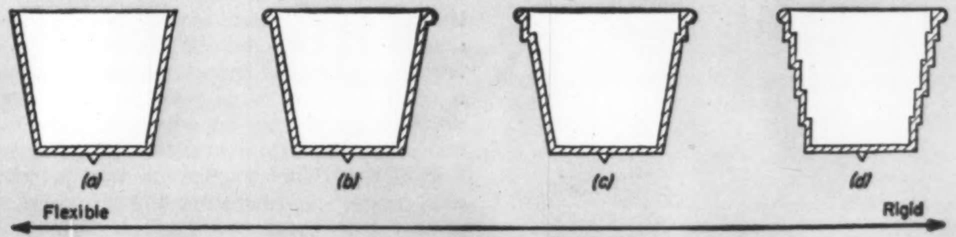


Fig. 6—Effect of step design on rigidity of thin-walled plastic cups. Design *a* is most flexible, *d*, most rigid.

cent thinner, depending on design, only rubber-modified styrene should be used.

Vacuum Forming: A somewhat limiting factor in the injection-molding process is high initial cost of precision steel molds. This drawback is nonexistent in the vacuum forming process, in which thermoplastic materials of high tensile elongation properties are particularly suited to forming thin-walled parts of large area. The fact that these materials have high tensile elongation and great impact strength, yet retain rigidity, has led to many advantages in designing a thin-walled part where formerly thicker wall sections were used.

Developments in the vacuum-forming process for sheet materials have made it especially suitable for parts having large area-to-weight ratios. Molds may be made for as little as 20 per cent of the cost of an injection mold for the same part and can be designed with movable cores to form undercuts. Holes can be punched during the trimming process after the sheet has been formed. A significant fact is that a sheet is used instead of a molding material, which means that the final part may be designed with a thinner wall section because of the lower stress level inherent in the sheet.

Door liners made by injection molding have larger cross-section than those made by vacuum forming. Thinner doors were known to be structurally sound, but could not be made by the injection-molding process. Vacuum-formed door-liners with wall section thicknesses reduced to as low as 0.080 in. are performing satisfactorily. Thinner wall sections have not only reduced material costs, but have eliminated high mold costs inherent in the injection-molding process.

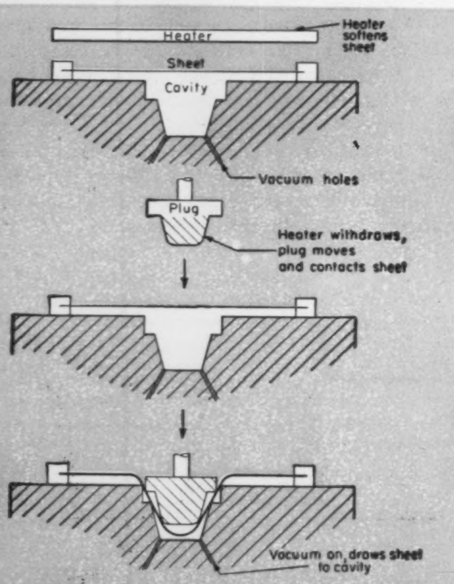

Heater
Heater softens sheet
Sheet
Cavity
Vacuum holes
Plug
Heater withdraws, plug moves and contacts sheet
Vacuum on, draws sheet to cavity

Fig. 7—Drape-assist technique in vacuum forming. Descent of plug and sheet into cup cavity prevents thinning of the sheet in critical areas at the cup bottom as in conventional vacuum forming.

Automatic Molding: Another important development of recent years is in high-speed automatic molding. Injection speeds in microseconds have permitted molding of parts with 0.014-in. wall sections. Low weights, with resulting material savings, have made thin-wall plastic items competitive with those of paper and other low-cost materials.

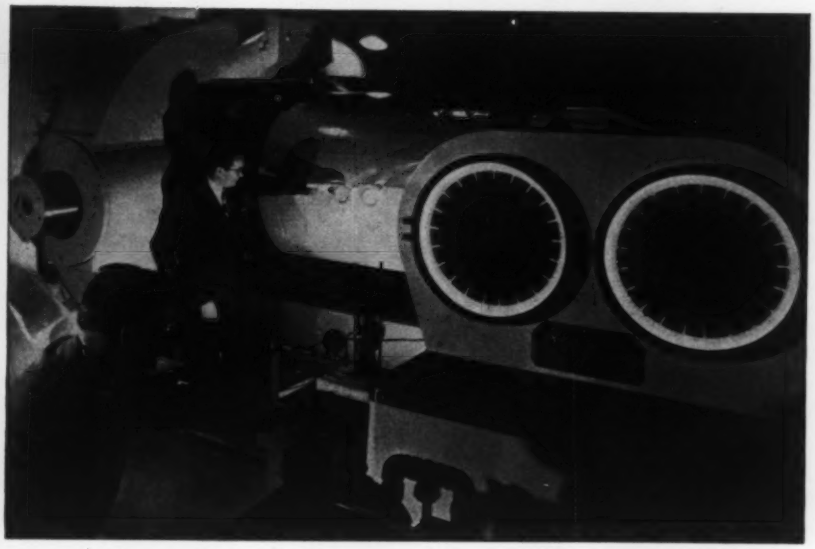
The first injection-molded coffee cups were those of the design shown in Fig. 6*b*. These cups were rigid, yet had only one rim designed for cam action drop-release in vending machines. However, the cup had a large degree of taper which gave it a slightly unwieldy appearance and caused some sticking in the machines. This design was modified as shown in Fig. 6*c*, which allowed slightly increased resistance to flexing and more stiffness, but still permitted adequate dispensing operation.

High-Production Forming: Techniques of vacuum forming cups from sheet material have resulted in a process now ready for commercial utilization. One advantage of sheet forming over injection molding is that many more cavities can be used for the particular item produced. In some cases, 40 cavities are required for vacuum forming cups as compared to two cavities for injection molding in typical high-speed, automatic injection-molding machines. Another advantage is that thinner sheets may be used in vacuum forming because of the lower stress set up in the forming operation. Economies such as these are of prime importance.

One problem encountered in vacuum forming the styrene cup was the deep draw necessary as compared to the cup diameter. Considerable thinning out of the bottom of the cup occurs in the process if a special technique is not used.

Drape Assist Technique: The drape assist technique, Fig. 7, is commonly used to form thin walls from sheet material. A plug descends into the cup, and vacuum is applied when the sheet is near the bottom of the cavity. At this point, the material has not yet thinned out as it does during conventional vacuum forming. A much more consistent wall-section is obtained, and less thinning occurs in critical areas at the bottom of the cup. Production rates as much as ten times that of conventional injection molding have been achieved.

After vacuum forming, a die cutting operation is necessary since parts require trimming from the sheet. This contrasts with molded articles which are ejected finished from the molds. Trimming is a limiting factor to date in the vacuum-forming process and prevents full advantage being taken of high production rates available with this process. Cost of the trimming operation must be taken into consideration in comparing the economics of one process with those of the other. Both the injection-molded cup of Fig. 6 and the vacuum-formed cup of Fig. 7 are examples of how part design yields flexibility or rigidity requirements according to the thin-wall concept.



Reduced-scale structural models, such as this fuselage section under test in the NACA Langley Laboratory, offer practical and economical solutions to problems of material selection and structural proportioning. As in all model testing, problem is to relate model and full-scale item performance. This article shows how.

Finding scale factors for Structural-Test Models

• deformation • stiffness • stability • strength • vibration •

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ADVANCES in engineering design in recent years have accentuated a multitude of stress-distribution problems. For the most part, they have remained unsolved—except perhaps, by empirical approximation. In spite of important progress in theoretical methods of attack, many solutions are still based on simplifying assumptions. Where the problem is complicated, however, simplification is hazardous.

Discontinuities, presence of holes, difficult edge or boundary conditions are all factors that make analysis difficult. In such cases, theoretical analysis cannot be fully relied upon to estimate strength and deformation with tolerable accuracy. The designer is thus faced with two alternatives: 1. To strengthen the structure at danger points. 2. To check its strength by tests. The latter course is more feasible. But tests—particularly tests to destruction of full-scale components—are generally costly. A more economic form of testing is obviously required.

Prototype Models: The traditional approach to the problem calls for the testing of small scale models of the prototype. This technique can be effective, provided that geometric similarity in structure and loading is achieved. Assuming that this is possible, the problem of translating test values obtained from the model to the full-scale component must be solved. It is therefore necessary to establish relationships that connect behavior of the model and the prototype. Such relationships are reviewed in this article.

Strength, deformation, stiffness, stability, and vibration are guiding criteria in engineering design. A theoretical or test investigation must therefore aim at determining one or more of those parameters. It follows that a general solution of the problem consists of a number of expressions, each specifying the interrelationship between model and prototype for a particular parameter.

Linear Deformation: The most effective approach for deducing relationships connecting model and full-scale component is through the theory of dimensions. Mechanics of application of this theory are detailed in this section for the linear-deformation relationship of the model and prototype.

The first step is to consider every factor that can possibly influence displacement. It is clear that linear deformation δ must depend on the magnitude of the applied load P, and upon the size of the structure conveniently represented by a linear dimension l. In addition, there are the moduli of elasticity E and G. When the influence of the weight of the structure is ignored, the overall effect of these factors can be summarized in a single expression:

$$\delta = f(P, l, E, G) \tag{1}$$

Here, f stands for "function of." Equation 1 is applicable provided that the structure behaves elastically.

Regardless of its actual form, Equation 1 must be capable of being represented by a series of terms of the form

$$\delta = \Sigma(P^u, l^v, E^w, G^x) \tag{2}$$

Value of the indices may vary from term to term, but their interrelationship must be such as to yield a dimension of length. If M, L, and T denote mass, length, and time, this condition may be expressed as

$$L = (MLT^{-2})^u (L)^v (ML^{-1}T^{-2})^w (ML^{-1}T^{-2})^x \tag{3}$$

When powers of M, L, and T on both sides of the equation are compared, it can be shown that the value for linear displacement is

$$\delta = lF\left[\left(\frac{El^2}{P}\right)\left(\frac{Gl^2}{P}\right)\right] \tag{4}$$

where F stands for "function of."

With the model designated by suffix m, model displacement is similarly given by

$$\delta_m = l_m F_m\left[\left(\frac{E_m l_m^2}{P_m}\right)\left(\frac{G_m l_m^2}{P_m}\right)\right] \tag{5}$$

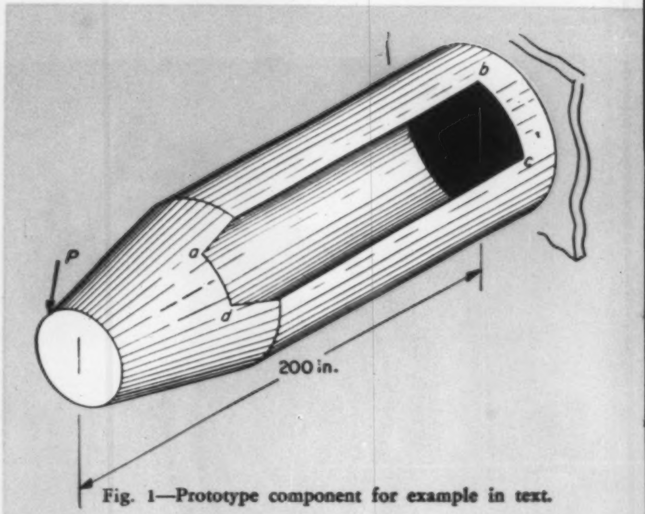


Fig. 1—Prototype component for example in text.

Also,

$$\frac{\delta}{\delta_m} = \frac{l}{l_m} \tag{6}$$

provided that

$$\frac{El^2}{P} = \frac{E_m l_m^2}{P_m} \tag{6.1}$$

$$\frac{Gl^2}{P} = \frac{G_m l_m^2}{P_m} \tag{6.2}$$

Equations 6.1 and 6.2 and, in consequence, Equation 6 are of fundamental importance to the problem under discussion. The significance of these equations results in the following conclusions:

1. If shear stresses do not contribute to deflection (as is the case in flexible beams) Equation 6.2 may be omitted. Equation 6 is applicable, and from Equation 6.1,

$$P = P_m\left(\frac{l}{l_m}\right)^2\left(\frac{E}{E_m}\right) \tag{7}$$

This means that the load on the prototype, applied in the same manner as that for the model, is

$$\left(\frac{l}{l_m}\right)^2\left(\frac{E}{E_m}\right)$$

times greater, while the deflection given by Equation 6 is l/l_m times that of the model.

2. If shear stresses are paramount in contributing towards deflection (as is the case in rigid structures) Equation 6.1 may be neglected. Equation 6 is applicable and from Equation 6.2,

$$P = P_m\left(\frac{l}{l_m}\right)^2\left(\frac{G}{G_m}\right) \tag{8}$$

This means that the load on the prototype, applied in the same manner as for the model, is

$$\left(\frac{l}{l_m}\right)^2\left(\frac{G}{G_m}\right)$$

times greater, while the deflection given by Equation 6 is l/l_m times that of the model.

3. If both shear and direct stresses contribute towards deflection, it is essential that

$$\frac{E}{G} = \frac{E_m}{G_m}$$

In the event that this relation is not satisfied, Equations 6.1 and 6.2 are not compatible, and Equation 6 is no longer applicable. If, however, this condition is satisfied, then either Equation 7 or Equation 8 may be applied.

Angular Rotation: The relationship connecting angular rotations of the model and of the full-scale structure is determined in precisely the same manner as for linear displacement. If the applied torque is t, and if shear stresses are not predominant in contributing to the angular rotation (as may be the case in combined torsion and bending),

$$t = t_m \left(\frac{l}{l_m} \right)^3 \left(\frac{E}{E_m} \right) \tag{9}$$

and

$$\frac{\theta}{\theta_m} = 1$$

If shearing stresses are predominant,

$$t = t_m \left(\frac{l}{l_m} \right)^3 \left(\frac{G}{G_m} \right) \tag{10}$$

If both direct and shear stresses contribute to angular rotation, and if

$$\frac{G}{E} = \frac{G_m}{E_m}$$

Then

$$\begin{aligned} t &= t_m \left(\frac{l}{l_m} \right)^3 \left(\frac{E}{E_m} \right) \\ &= t_m \left(\frac{l}{l_m} \right)^3 \left(\frac{G}{G_m} \right) \end{aligned} \tag{11}$$

Linear Stiffness: By definition, linear stiffness is load per unit displacement, that is P/δ. When Equations 6 and 6.1 are applied, linear stiffness of the full-scale structure is given by

$$\frac{P}{\delta} = \left(\frac{P_m}{\delta_m} \right) \left(\frac{l}{l_m} \right) \left(\frac{E}{E_m} \right) \tag{12}$$

Angular Stiffness: Angular stiffness is defined as torque per radian, that is T/θ. With the use of Equation 9, the angular stiffness of the full scale structure is

$$\frac{t}{\theta} = \left(\frac{t_m}{\theta_m} \right) \left(\frac{l}{l_m} \right)^3 \left(\frac{E}{E_m} \right) \tag{13}$$

Elastic Stability: The dominant factors influencing elastic instability are the moduli of elasticity E and G and the size l of the structure. From the theory of dimensions:

$$P_s = El^2 F \left(\frac{G}{E} \right) \tag{14}$$

For the model, then

$$P_{sm} = E_m l_m F_m \left(\frac{G_m}{E_m} \right) \tag{15}$$

From these expressions, the following conclusions can be reached:

1. If failure depends on both G and E, then

$$P_s = P_{sm} \left(\frac{l}{l_m} \right)^2 \left(\frac{E}{E_m} \right) \tag{16}$$

This expression is valid provided $G/E = G_m/E_m$, which implies that shear stresses have an important effect.

2. If shear stresses are paramount in causing failure, then

$$P_s = P_{sm} \left(\frac{l}{l_m} \right)^2 \left(\frac{G}{G_m} \right) \tag{17}$$

3. If failure depends on E alone, which implies that the effect of shear stresses may be neglected, then

$$P_s = P_{sm} \left(\frac{l}{l_m} \right)^2 \left(\frac{E}{E_m} \right) \tag{18}$$

Strength: The method of obtaining load P_f which would cause a structure to fail is similar in all respects to that used in deriving the preceding relationships. However, a factor not used before—but one which influences failure — is the failing stress s of the material. When this factor is included, the basic expression becomes

$$P_f = sl^2 F \left[\left(\frac{E}{s} \right) \left(\frac{G}{s} \right) \right] \tag{19}$$

Similarly, for the model

$$P_{fm} = s_m l_m{}^2 F_m \left[\left(\frac{E_m}{s_m} \right) \left(\frac{G_m}{s_m} \right) \right] \tag{20}$$

This leads to the following conclusions:

1. If failure is due to direct stresses (say tension or compression), then the failing load is clearly independent of G and E. Therefore,

$$P_f = \left(\frac{l}{l_m} \right)^2 \left(\frac{s}{s_m} \right) P_{fm} \tag{21}$$

2. If failure is due to a combination of direct and bending stresses, the effect of E cannot be ignored. Equation 21 is applicable, provided that $E_m/s_m = E/s$.

3. If direct, bending, and shear stresses affect failure, then Equation 21 is applicable, provided that $E/s = E_m/s_m$ and $G/E = G_m/E_m$. These restrictive conditions are apparent from the basic Equations 19 and 20.

It may be concluded that a practical test procedure is to make the model of the same material as the prototype. In that event, the failing load for all types of failure (stability included) is given by

$$P_f = \left(\frac{l}{l_m} \right)^2 P_{fm} \tag{22}$$

Natural Frequencies: The natural frequency of a vibrating body is given by

$$f = \frac{1}{2\pi}\sqrt{\frac{\text{acceleration}}{\text{displacement}}} \tag{23}$$

If the natural frequency of a body of density ρ is due to linear motion, then

$$f = \frac{1}{2\pi}\sqrt{\frac{P/\delta}{\rho l^3}}$$

$$= \frac{1}{2\pi}\sqrt{\left(\frac{P_m}{\delta_m}\right)\left(\frac{l_m}{l}\right)\left(\frac{E}{E_m}\right)\left(\frac{1}{\rho l^3}\right)} \tag{24}$$

Similarly, for the model

$$f_m = \frac{1}{2\pi}\sqrt{\frac{P_m/\delta_m}{\rho_m\, l_m{}^3}} \tag{25}$$

from which

$$f = \left[\frac{(1/l)\sqrt{E/\rho}}{(1/l_m)\sqrt{E_m/\rho_m}}\right] f_m \tag{26}$$

By the same approach, the torsional natural frequency is given by an identical expression.

Example: To illustrate application of the various relationships obtained in the foregoing analysis, consider the component shown in Fig. 1. This is a steel cylindrical shell with a rectangular cutout *abcd* on one side. It is rigidly held as shown, and load P is applied at the free end. The following information is required with regard to the prototype:

1. Linear displacement.
2. Linear stiffness.
3. Stability characteristics.
4. Ultimate strength.
5. Natural frequency.

The following data pertain to the prototype: $E = 30 \times 10^6$ psi; $G = 12 \times 10^6$ psi; $G/E = 1/2.5$; $s = 120{,}000$ psi; $l = 200$ in.

Data pertaining to the model constructed for testing are as follows: Material, aluminum alloy; $E = 10 \times 10^6$ psi; $G = 4 \times 10^6$ psi; $G/E = 1/2.5$; $s = 40{,}000$ psi; $l_m = 10$ in.

Test values obtained from the model are as follows:

1. When $P_m = 10$ lb, $\delta_m = 0.01$ in.
2. Initial buckling occurred at $P_{sm} = 25$ lb.
3. Ultimate failure occurred at $P_{fm} = 75$ lb.
4. Natural frequency = 500 cps.

Based on these model test values, the corresponding behavior of the prototype is as follows:

Linear Displacement: From Equation 6, the displacement of P is

$$\delta = \frac{\delta_m\, l}{l_m} = 0.01\left(\frac{200}{10}\right) = 0.2 \text{ in.}$$

The corresponding load that produces this deflection, bearing in mind that $G/E = G_m/E_m$, is obtained from Equation 7 as

$$P = P_m\left(\frac{l}{l_m}\right)^2\left(\frac{E}{E_m}\right)$$

$$= 10\left(\frac{200}{10}\right)^2\left(\frac{30 \times 10^6}{10 \times 10^6}\right) = 12{,}000 \text{ lb}$$

Linear Stiffness: By definition, linear stiffness is

$$\frac{P}{\delta} = \frac{12{,}000}{0.2} = 60{,}000 \text{ lb per in.}$$

This result can also be obtained by applying Equation 12.

Stability: The load causing initial instability in the prototype is obtained by applying Equation 16, or

$$P_s = P_{sm}\left(\frac{l}{l_m}\right)^2\left(\frac{E}{E_m}\right)$$

$$= 25\left(\frac{200}{10}\right)^2\left(\frac{30 \times 10^6}{10 \times 10^6}\right) = 30{,}000 \text{ lb}$$

Ultimate Strength: Ultimate strength of the prototype is given by Equation 21 as

$$P_f = \left(\frac{s}{s_m}\right)\left(\frac{l}{l_m}\right)^2 P_{fm}$$

$$= \left(\frac{120{,}000}{40{,}000}\right)\left(\frac{200}{10}\right)^2 (75) = 90{,}000 \text{ lb}$$

This is because

$$\frac{E}{s} = \frac{E_m}{s_m} \quad\text{and}\quad \frac{G}{E} = \frac{G_m}{E_m}$$

Natural Frequency: The natural frequency of the prototype is given by Equation 26 as

$$f = \left[\frac{(1/l)\sqrt{E/\rho}}{(1/l_m)\sqrt{E_m/\rho_m}}\right] f_m$$

$$= \left[\frac{(1/200)\sqrt{(30 \times 10^6)/0.3}}{(1/10)\sqrt{10 \times 10^6/0.1}}\right](500) = 25.6 \text{ cps}$$

They Say . . .

"Even given a full cadre of skilled specialists assigned to the various laboratory functions, there would still be an urgent need for supervisors and group leaders capable of integrating all these individual efforts. These and succeeding levels of technical management must appreciate the potentialities of the various laboratory tools and techniques. Also, such individuals must understand the economics of the marketplace, have a knowledge of the present product line in the area being researched and, last but not least, be keen students of human psychology with ability to work with and through people and able, most of all, to inspire those in their charge."—Emil Ott, *director of research, and* Carl Prutton, *executive vice president, Food Machinery and Chemical Corp.*

High-strength steel foil stiffened locally results in a lightweight structure with which weight savings of up to 60 per cent are possible over original parts designed for conventional fabrication

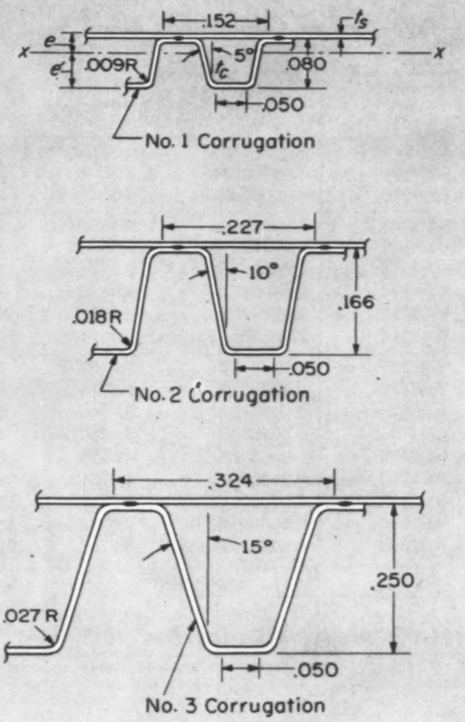


Fig. 1—Standard corrugations used to evaluate structures. Corrugations larger than No. 3 are not desirable because individual stiffeners become practical for stiffening sheet above 0.016-in. thickness.

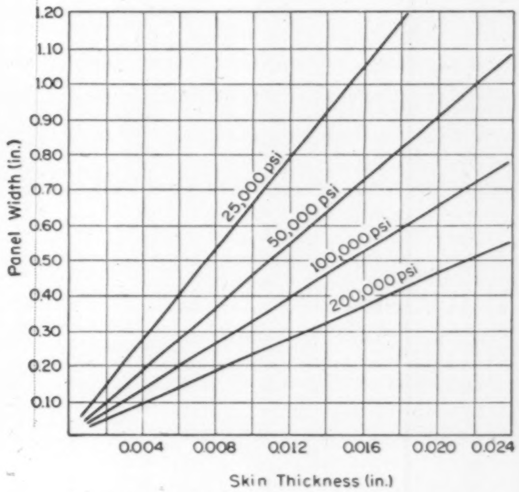


Fig. 2—Allowable buckling stress for steel panels. A K factor of 3.6, derived from the formula for buckling, indicates certain practical considerations in corrugation design, i.e., stiffener spacing for each skin thickness.

Steel-Foil Corrugated Panels

for lightweight, high-strength structures

By **BRUCE MITCHELL**
Chief of Structures
Ryan Aeronautical Co.
San Diego, Calif.

A STUDY of structures combining low weight and high strength has led to the use of steel foil stiffened locally with miniature corrugations, Fig. 1. Parts made with these corrugated skins show weight savings from 18 to 60 per cent over similar parts of conventional construction. For example, aircraft firewalls made from 0.002-in. Type 321 steel sheet welded to No. 1 corrugations of the same material show a weight saving of 60 per cent over the original part designed for fabrication from 0.016-in. sheet.

Steel was selected for the corrugated-skin construction because it is the only high-strength material available in extremely thin sheet. In thicknesses of only 0.001 in., steel foil can be heat treated to develop the same high-strength characteristics that it possessed before rolling. In addition, its exceptionally good welding and forming characteristics and elevated-temperature properties make it applicable for structures subjected to high temperature.

Corrugation Materials: One of the best steels for this lightweight corrugated structure is 17-7 PH. It is particularly desirable because it can be heat treated without scaling. The theoretical strength-to-weight advantage of steel over aluminum and magnesium, for example, at room temperature and at elevated temperatures can be a practical advantage if the full available strength of the steel is used. Room-temperature yield strength of 17-7 PH is 200,000 psi. This means that a piece of this steel 1 in. wide and 0.001 in. thick can carry an axial load of 200 lb. In order to exploit this high strength, ways of stabilizing this sheet for compression loads of this magnitude, or of collecting the load and concentrating the material until stabilization is possible, must be devised.

Design Factors: Fig. 2 shows allowable buckling stress of steel panels with a *K* factor of 3.6. This figure indicates a required stiffener spacing of 0.50 in. for 0.022-in. skin, or 0.10 in. for 0.0045-in. skin for nonbuckling at a stress of 200,000 psi. Practical considerations rule out individual stiffeners spaced closer than 3/8 in. This forced the consideration of miniature corrugations as a practical means of obtaining closely spaced stiffeners.

Design of the miniature corrugations shown in Fig. 1 is a compromise between theoretical and practical considerations. These corrugations are necessarily symmetrical because of details of structural assembly. The 0.050-in. dimension of the flat face of the corrugation is dictated by spot-welding requirements. Tests indicate enough fixity in corners to permit a *K* factor of 5.3 in the buckling formula. Nonbuckling to a stress of 200,000 psi established corrugation depth. Pitch is based on nonbuckling limits of a skin of twice the thickness of the corrugation material.

Practical considerations require a limitation on number of standard sizes. Three sizes shown in Fig. 1 were arrived at after careful consideration of all factors involved. Corrugation No. 1 has a top gage limit of 0.003 in. No. 2 has a top gage limit of 0.006 in., and No. 3 has a top gage limit of 0.009 in. Corrugations larger than No. 3 are not desirable because individual stiffeners become practical for stiffening sheet above 0.016 in. thickness. Section properties and

Table 1—Properties of Corrugations Alone

Corrugation No.	Corrugation Thickness, t_c (in.)	Section Area per Inch of Corrugation (in.²)	Moment of Inertia, I_{z-z}, per Inch of Corrugation (in.⁴)	Radius of Gyration, ρ_{z-z} (in.²)	Buckling Allowable (psi)
1	0.001	0.00185	0.000001508	0.0285	24,000
	0.002	0.00368	0.000002945	0.0283	10,000
	0.003	0.00548	0.000004340	0.0281	23,000
2	0.001	0.00215	0.00000618	0.0536	15,000
	0.002	0.00424	0.00001221	0.0536	22,000
	0.003	0.00633	0.00001800	0.0533	50,000
	0.004	0.00840	0.00002360	0.0530	90,000
	0.005	0.01042	0.00002900	0.0527	143,000
	0.006	0.01243	0.00003415	0.0524	200,000
3	0.001	0.00210	0.0000123	0.0767	2,300
	0.002	0.00419	0.0000243	0.0762	9,300
	0.003	0.00626	0.0000362	0.0760	21,000
	0.004	0.00832	0.0000477	0.0757	38,000
	0.005	0.01040	0.0000591	0.0754	60,000
	0.006	0.01240	0.0000704	0.0753	87,000
	0.007	0.01440	0.0000811	0.0750	119,000
	0.008	0.01640	0.0000916	0.0748	156,000
	0.009	0.01868	0.0001047	0.0748	199,000

Table 2—Properties of No. 1 Corrugation With Skin

Skin Thickness, t_s (in.)	Corrugation Thickness, t_c (in.)	Section Area per Inch of Corrugation (in.²)	e* (in.)	e'* (in.)	Moment of Inertia, I_{z-z}, per Inch of Corrugation (in.⁴)	Radius of Gyration, ρ_{z-z} (in.)	Buckling Allowable, Skin (psi)
0.001	0.001	0.00285	0.0268	0.0533	0.00000257	0.0300	4,500
0.002	0.002	0.00568	0.0275	0.0529	0.00000512	0.0300	18,000
0.003	0.003	0.00848	0.0284	0.0519	0.00000768	0.0301	41,000
0.004	0.003	0.00948	0.0263	0.0541	0.00000842	0.0298	72,000
0.005	0.003	0.01048	0.0247	0.0558	0.00000907	0.0294	113,000
0.006	0.003	0.00148	0.0237	0.0569	0.00000964	0.0290	163,000
0.007	0.003	0.01248	0.0227	0.0580	0.00001016	0.0286	200,000

*See Fig. 1

Table 3—Properties of No. 2 Corrugation With Skin

Skin Thickness, t_s (in.)	Corrugation Thickness, t_c (in.)	Section Area per Inch of Corrugation (in.²)	e* (in.)	e'* (in.)	Moment of Inertia, I_{z-z}, per Inch of Corrugation (in.⁴)	Radius of Gyration, ρ_{z-z} (in.)	Buckling Allowable, Skin (psi)
0.001	0.001	0.00315	0.0575	0.1095	0.0000108	0.0585	2,000
0.002	0.002	0.00624	0.0581	0.1099	0.0000224	0.0600	8,100
0.003	0.003	0.00933	0.0589	0.1101	0.0000324	0.0590	18,000
0.004	0.004	0.0124	0.0584	0.1116	0.0000446	0.0600	32,000
0.005	0.005	0.0154	0.0603	0.1107	0.0000537	0.0590	51,000
0.006	0.005	0.0164	0.0577	0.1143	0.0000572	0.0590	73,000
0.007	0.005	0.0174	0.0552	0.1178	0.0000604	0.0589	99,000
0.008	0.005	0.0184	0.0532	0.1208	0.0000633	0.0596	130,000
0.009	0.005	0.0194	0.0514	0.1236	0.0000660	0.0583	164,000
0.010	0.005	0.0204	0.0499	0.1261	0.0000699	0.0585	200,000
0.006	0.006	0.0184	0.0609	0.1111	0.0000641	0.0590	73,000
0.007	0.006	0.0194	0.0588	0.1142	0.0000677	0.0590	99,000
0.008	0.006	0.0204	0.0569	0.1171	0.0000710	0.0589	130,000
0.009	0.006	0.0214	0.0552	0.1198	0.0000742	0.0588	164,000
0.010	0.006	0.0224	0.0537	0.1223	0.0000771	0.0586	200,000
0.012	0.006	0.0244	0.0513	0.1267	0.0000825	0.0581	200,000

*See Fig. 1

calculated buckling allowable of webs of these three standard corrugations are given in Table 1.

Miniature corrugations welded to thin skin are rigid in one direction only and are very strong locally. They are too shallow, however, to have good column characteristics. It is not practical, in most cases, to attempt to provide enough supports to get the column length down to the short column needed for high stress. This corrugation - skin combination has good bending stiffness in one direction and can be used very effectively to beam pressure loads to other main supports. Section properties and skin buckling allowable of the various skin-corrugation combinations are given in Tables 2, 3 and 4. These properties were used in calculating the typical allowable pressure loading of Fig. 3. This pressure loading is based on a unit width of beam parallel to the corrugations and passing over many supports.

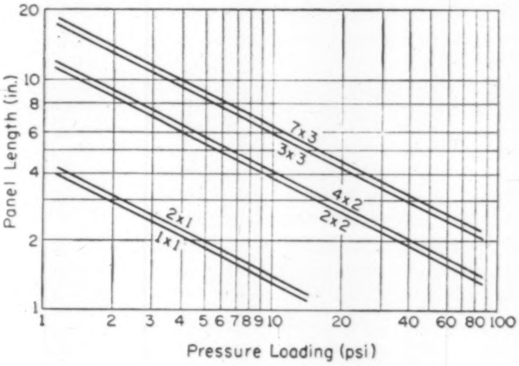
From a paper entitled "Designing with Steel for Lighter Aircraft," presented at the SAE National Aeronautic Meeting in Los Angeles, Calif., October, 1957.

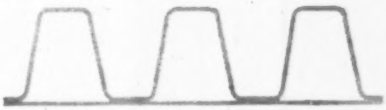
Table 4—Properties of No. 3 Corrugation With Skin

Skin Thickness, t_s (in.)	Corrugation Thickness, t_c (in.)	Section Area per Inch of Corrugation (in.^{2})	e* (in.)	e'* (in.)	Moment of Inertia, I_{z-z}, per Inch of Corrugation (in.^{4})	Radius of Gyration, ρ_{z-z} (in.)	Buckling Allowable, Skin (psi)
0.001	0.001	0.00310	0.0855	0.1655	0.0000230	0.0862	1,000
0.002	0.001	0.00410	0.0652	0.1868	0.0000286	0.0835	4,000
0.002	0.002	0.00619	0.0863	0.1657	0.0000458	0.0860	4,000
0.003	0.003	0.00926	0.0871	0.1659	0.0000687	0.0861	9,000
0.004	0.004	0.01232	0.0876	0.1664	0.0000914	0.0871	16,000
0.005	0.005	0.0154	0.0887	0.1663	0.0001141	0.0862	25,000
0.006	0.006	0.0184	0.0892	0.1668	0.0001367	0.0862	36,000
0.007	0.007	0.0214	0.0900	0.1670	0.0001588	0.0861	49,000
0.008	0.008	0.244	0.0906	0.1674	0.0001811	0.0863	64,000
0.009	0.009	0.277	0.0918	0.1672	0.0002066	0.0864	81,000
0.010	0.009	0.0287	0.0896	0.1704	0.0002148	0.0865	100,000
0.012	0.009	0.0307	0.0857	0.1763	0.0002302	0.0865	144,000
0.014	0.009	0.0327	0.0824	0.1816	0.0002441	0.0864	196,000
0.016	0.009	0.0347	0.0804	0.1856	0.0002572	0.0860	200,000
0.018	0.009	0.0367	0.0773	0.1907	0.0002694	0.0856	200,000

*See Fig. 1

Fig. 3—Allowable pressure loading for No. 1 corrugation with skin (corrugation critical). Figures 7 by 3, 3 by 3, etc., indicate 0.007-in. skin with 0.003-in. corrugation, and 0.003-in. skin with 0.003-in. corrugation, respectively.





High-Strength Steel Weldments

By B. R. ALSOBROOK
Rohr Aircraft Corp.
Chula Vista, Calif.

PROPERTIES of certain alloys are being evaluated to determine their capabilities in high-temperature applications. Fig. 1 shows the relationship of strength to temperature of a low-alloy steel and two aluminum alloys. Strength ratio of the steel to aluminum is approximately 2.34 to 1 at 300 F and increases to approximately 4.33 to 1 at 55 F. Beyond this temperature, there is no advantage to be gained by using an aluminum alloy. However, it is felt that low-alloy steels, if suitably protected, can be used to advantage in certain applications in the lower temperature ranges (from 600 F) where stainless steels are currently used.

High-Strength Weldments: Low-alloy steels in weldment form offer much in the way of low unit cost and producibility. Selection of low-alloy, high-strength steel weldments for certain structures automatically permits design flexibility that could not be achieved with equivalent forged or cast parts. Weldment designs can be developed which permit easy processing and fabrication of reliable parts at low cost. Automatic welding operations insure repeatability of product quality.

Current steel weldments of AMS 6434 steel joined with AISI 502 stainless steel are heat treated to 180,000 to 200,000 psi ultimate tensile strength. These weldments show strength and weight comparable to equivalent forged parts and exhibit highly consistent weld quality. It is also possible to make design changes for technical improvements or cost reduction at a minimum cost and loss of time.

Design Factors: Correct joint design is very important to successful welding for the following reasons:

1. Helps control distortion.
2. Minimizes residual stresses.
3. Aids good workmanship.
4. Promotes welding economy.
5. Permits maintenance of quality standards.

Service conditions are important factors affecting joint design. If corrosion or erosion environments are anticipated, then welded joints should have a minimum of surface irregularities, crevices, or other conditions that hasten susceptibility to attack. Consideration should be given to the manner in which loads are applied, whether in shear, tension, torsion, or bending. Certain joint designs are applicable for loads in one direction only, while others are suitable for varied and unpredictable stresses. It is also known that static or dynamic loading requires different joint designs.

Efficiency of a weld joint is an influencing factor in its design. Joint efficiency can be described as a percentage of strength of unwelded metal and is used to indicate strength of a welded joint.

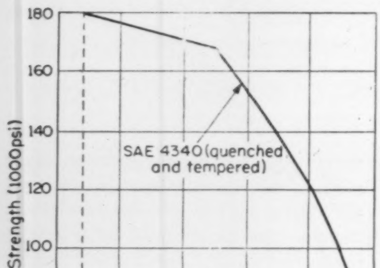


Fig. 1—Typical tensile properties of SAE 4340 steel and two aluminum alloys. Material specimens were less than ¼ in. thick. Data at elevated temperatures were obtained after 30 min exposure.

Manufacturing methods generally require gas welding on fillet-weld joints and metal arc-welding on butt-weld joints. Butt welds are square, or grooved with a Vee preparation, and generally involve complete penetration with backing.

Fig. 2 shows square-groove joint designs welded from one side with backing and complete penetration.

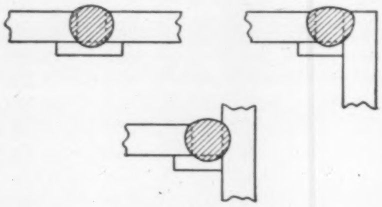


Fig. 2 — Square-groove joint designs welded from one side with backing. Complete joint penetration is shown. These joints are satisfactory for material thicknesses to 3/16 in.

These joints are suitable for all types of loading and are satisfactory for materials to 3/16 in. thick with adequate root opening. This particular design is economical from the standpoint of preparation. Single V-groove joints, welded from one side with backing and complete penetration, are shown in Fig. 3. These joints are suitable for all types of loading with full strength obtainable. Welding can be done economically in thicknesses to ¾ in. This joint is desirable when welding can be done on one side only.

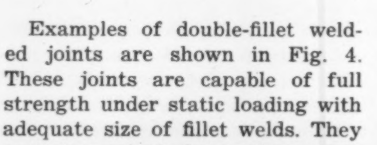


Fig. 3—Single V-groove joints welded from one side with backing. Complete joint penetration is shown. These joints are satisfactory for material thicknesses to ¾ in.

Examples of double-fillet welded joints are shown in Fig. 4. These joints are capable of full strength under static loading with adequate size of fillet welds. They are economical from the standpoint of welding and require no special preparation. Maximum strength in tension on the lap joint is acquired when the lap equals five times the thickness of the thinner member.

Fabrication Control: Welding of low-alloy high-strength steels involves heating the steel from a slightly elevated temperature to a temperature exceeding its transformation point and cooling it to a temperature below black heat. Associated with heating and cooling during the welding process are those factors that create a need for process control, i.e., expansion and contraction of the steel, changes in physical properties, and metallurgical and gaseous effects. Reliable weldments can be economically produced through correct design and process control.

Typical of the welding processes used on low-alloy, high-strength steel is the metal arc-process. Welding is done with reverse-polarity direct current. Electrodes are of the 502 analysis, low hydrogen type in the stainless-steel category. In addition to providing satisfactory physical properties in the weld, this rod is a smooth-running one that leaves a porosity-free deposit. Welding fixtures and holding equipment are designed to permit most welds to be made in the flat or down-weld position. This permits easier welds and assures better quality.

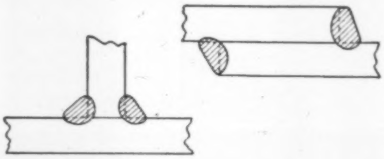


Fig. 4—Double-fillet welded joints. These joints are capable of full strength under static loading with adequate-size fillets.

Prior to welding, holding fixture and parts are preheated at 350 to 450 F. If welding is interrupted before completion, the part in its fixture should be held at the preheat temperature until welding can be resumed.

Heat Treating: The completed weldment is post-heated at 350 to 600 F prior to stress relief. It is then transferred to a holding oven or furnace for stress relief at

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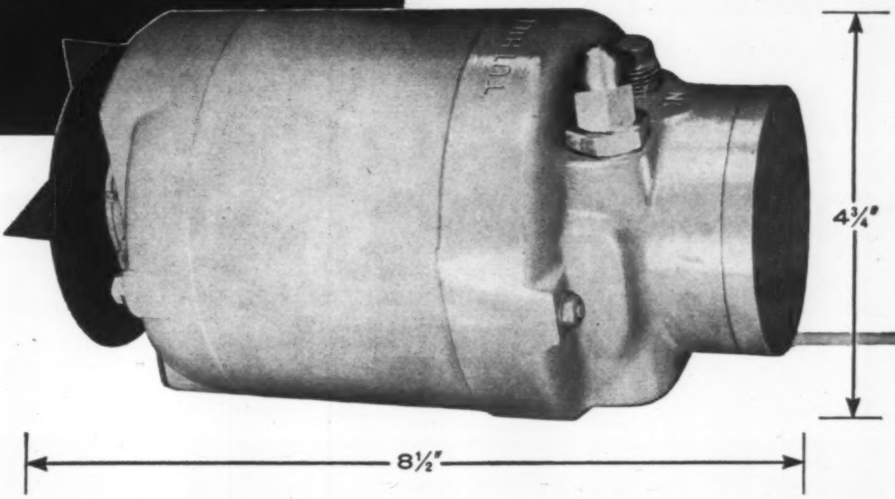

Here's another example of Tuthill's ability to develop the pump to fit the problem. This compact, new Powermite motor-pump combination, a Tuthill exclusive, was developed to meet the requirements of original equipment manufacturers with unusual space and weight limitations.

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The pump section contains a built-in strainer, and, if desired, an adjustable relief valve. Powermite can be furnished with cooling blower, as illustrated, or it may be supplied with a shaft extension for driving other accessories.

Powermite can be furnished in a wide variety of pump and motor combinations for use in hydraulic, oil burning, lubricating, and other services involving many different fluids. For example, the model illustrated has a capacity of 18 gallons per hour at 300 psi, and is driven by a 1/12 hp motor at a speed of 1750 rpm.

Manufacturers desiring to investigate the cost, space and weight saving advantages of incorporating Powermites into their products are invited to submit detailed specifications. Or, if preferred, a Tuthill representative will call.

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1200 F for 20 min. Transfer is made before the weldment shows an appreciable heat loss. Post-heat-treatment prevents weld embrittlement and relieves stresses caused by expansion and contraction. After stress relief, parts are transferred to salt-bath heat-treating furnaces for final heat treatment. Salt-bath heat treating is preferred over atmosphere-furnace heat treating because heating is done quickly and uniformly with minimum distortion and tends to clean the weldment.

Weldment Advantages: The following points summarize advantages of high-strength steelweldments:

1. High-strength steel weldments, suitably protected, are adaptable to high-temperature applications replacing stainless steel in some cases.
2. Weldments offer a definite advantage in flexibility of design and fabrication. Changes can be incorporated into production with minimum cost and time loss.
3. With currently established radiographic standards and weld quality, there is every indication that present design allowables of 120,000 psi ultimate and 80,000 psi limit loading for weldments can be increased by 19,000 to 40,000 psi.
4. Processing of parent material through operations such as plating, descaling, and grinding has a pronounced effect on fatigue life and must be considered in design along with allowable weld imperfections.
5. Weldments embody those attributes of producibility, manufacturability, and reliability that are necessary for expedient deliveries at low cost.

From a paper entitled "The Role of High Strength Weldments in Aircraft Structure," presented at the SAE National Aeronautic Meeting in Los Angeles, October, **1957.**

New DC Armature Winding

affords flexibility in motor and generator design

By **WILLIAM E. MENZIES**
Delco Products Div.
General Motors Corp.
Dayton, Ohio

A new balanced-network multiplex wave winding eliminates the undesirable equalizing currents and heating losses associated with presently used basic types of armature windings and makes a more efficient motor or generator

IMPORTANT in the overall design of a dc motor or generator is the design of the armature and its component conductors. Voltage developed, current-carrying capacity, kilowatt or horsepower output, and speed are directly dependent on the proper design and operation of the armature. The number of armature conductors and the number of parallel paths through the armature constitute primary design considerations and have a direct bearing on the type of armature winding used.

Two basic types of armature windings are used today—the lap, or parallel, winding and the wave, or series, winding. However, certain inherent characteristics and limitations related to these windings gave rise to the need for developing a new type, Fig. 1*a*.

In the design of an armature for a dc machine of a given size, voltage, and speed, use of a wave winding may result in too few commutator bars for good commutation. Therefore, it is customary to use a lap winding with equalizer connections which join in parallel coils. These equalizer connections cause commutator bars to be tied together electrically at any instant, thus providing a path for flow of equalizing currents. Because of heat losses produced, equalizing currents are undesirable but unavoidable if potential equalization and good commutation with a lap winding are needed.

Magnetic unbalance, also a cause of equalizing currents, is often difficult to avoid in dc machines because of design considerations. In some instances, magnetic unbalance of a high order is often introduced purposely to improve stability. Whenever this is necessary, use of a winding with equalizers is ruled out because of the accumulative effect of heat losses. Therefore, value of a winding in which such currents are absent is obvious even for machines without magnetic unbalance. The new winding shown in Fig. 1 meets such a need.

Present Multiple-Path Windings: Multiplex windings—that is, lap or wave windings consisting of two or more single windings wound in parallel on the armature core—as a means of obtaining multiple paths are generally regarded as unsatisfactory in practice.

Multiplex windings are composed of a number of single or multiple re-entrant windings, or branches. Each winding is associated with a succession of commutator bars proportionally interspread among commutating bars of the other branches. Branches are paralleled only through brush-surface contact with their associated bars. After a period of operation, the commutator bars associated with one branch become blackened, causing objectionable sparking. This condition usually becomes worse until there may be considerable sparking, even at no load.

New Multipath Armature Winding: A multiple-path winding having the desirable characteristics of a wave winding and free of equal-

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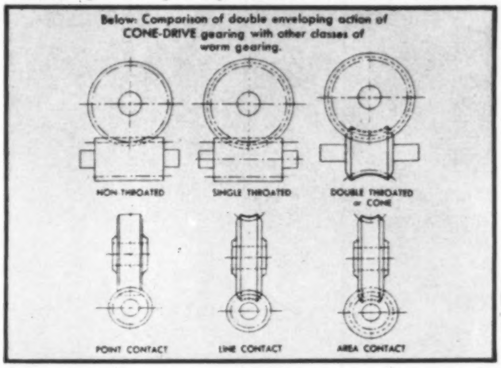
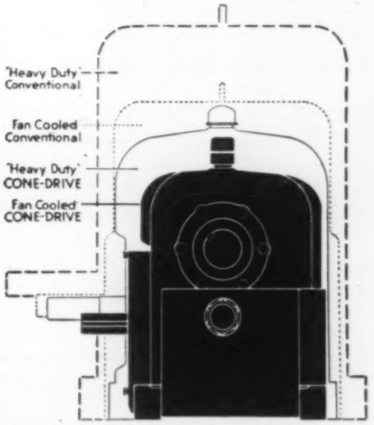
How to get the most out of Worm Gearing

If a right-angle drive is needed in your product and you require maximum capacity for your dollar, then the Cone-Drive double-enveloping type will give it to you. The sketch below shows the apparent advantages of Cone-Drive gearing as compared to other worm gear types. Double-enveloping worm gearing, the most modern and efficient form, has straight-sided teeth in both worm and gear. Both elements of Cone-Drive are throated and envelop each other, providing a multiple tooth area contact. This means greater load-carrying capacity than is possible with any other type of worm gearing.


Below: Comparison of double enveloping action of CONE-DRIVE gearing with other classes of worm gearing.
NON THROATED
SINGLE THROATED
DOUBLE THROATED or CONE
POINT CONTACT
LINE CONTACT
AREA CONTACT

Speed reducers and gearmotors with Cone-Drive double-enveloping worm gearing are unusually compact and powerful drives that handle shock loads with ease. Yet, they provide power transmission smoother than that of hydraulic systems. Another advantage, unique to double-enveloping worm gearing, is their ability to regenerate themselves when wear occurs. Both worm and gear tend to reproduce the correct form in the other when wear occurs.

Double-enveloping worm gearing is available from Cone-Drive Gears in complete lines of gearsets, speed reducers and gearmotors. Gearsets are stocked in center distances from 2" thru 24", capable of handling loads from fractional to over 1600 horsepower. A complete line of mountings for gearsets is also stocked.


"Heavy Duty" Conventional
Fan Cooled Conventional
"Heavy Duty" CONE-DRIVE
Fan Cooled CONE-DRIVE

Double-enveloping worm gearing with its "wrap-around design" requires shorter center distances than cylindrical worm gearing to handle the same loads. As a result, Cone-Drive speed reducers have smaller housings with corresponding savings in weight and space. Bulky gear trains can often be replaced with a single Cone-Drive speed reducer or gearset.

DOUBLE-ENVELOPING WORM GEARSETS · **DOUBLE-ENVELOPING WORM GEAR SPEED REDUCERS** · **DOUBLE REDUCTION WORM GEAR SPEED REDUCERS** · **DOUBLE-ENVELOPING RIGHT ANGLE GEARMOTORS**

Please send me information on following:

☐ **Gearsets** ☐ **Gearmotors** ☐ **Speed Reducers**

Name____________________

Title____________________

Company____________________

Street____________________

City____________________State__________

CONE-DRIVE GEARS

DIVISION MICHIGAN TOOL COMPANY

7171 E. McNichols Road • Detroit 12, Michigan
Telephone: TWinbrook 1-3111

TEAR OUT AND MAIL IN FOR COMPLETE DATA

TEAR OUT AND MAIL IN FOR COMPLETE DATA

TEAR OUT AND MAIL IN FOR COMPLETE DATA

Circle 490 on Page 19

izing currents has been developed.

The balanced-network dc armature winding has the separate windings, or branches, paralleled internally. In the network thus formed, equalizing currents or magnetic equalization is nonexistent. The internal paralleling consists of connecting certain equipotential points to obtain internal voltage balance and a definite potential relationship between adjacent commutator bars. For example, interconnections joining commutator bars 20 and 2, and 22 and 4, Fig. 1*b*, connect two coils with sides lying in slots 2 and 4 and slots 6 and 8 in parallel with two coils with sides lying in the same slots. Each coil is connected between adjacent commutator bars, Fig. 1*c*, in the same manner as coils in a lap winding, Fig. 1*d*. Thus, voltage between adjacent bars is always that voltage associated with a single coil.

Commutating pole strengths are determined by load current, external to the armature. Therefore, in armature windings having multiple paths, the various paths divide load current equally for optimum commutation, since they are influenced by the same commutating pole fluxes. In the multiplex wave winding under consideration, the interconnections assure a nearly uniform division of load current among various branches of the armature winding. Even if the division of load current at the brush surface is uneven between the commutator bars associated with the various branches of the winding, the paralleling junctions formed by the interconnections cause load current to divide in a nearly uniform manner among branches.

Interconnections are connected in parallel between the branches to carry jointly only that portion of the load current represented by the lack of uniform division at the brush surface. As a result, current carried by each interconnection is small and the cross section needed for the interconnection is small. Actually, the size of the interconnection is usually determined by mechanical strength rather than electrical conductivity.

The balanced-network, multiple-path armature winding has been applied to dc machines having more than four poles. With this type of winding the number of parallel paths is not limited to the number of poles. Many six-pole machines having four parallel paths have been built. An eight-pole machine may have four, six, or eight parallel paths. In fact, it is not entirely impractical to have the number of paths equal to twice the number of poles.

In a four-pole equalized lap winding, only an even number of slots may be used. With the balanced-network multiplex wave winding it is not necessary to use a number of slots which is divisible by half the number of poles, Fig. 1. A greater degree of flexibility is available, therefore, than is afforded by a lap-wound armature.

From "Electrical Engineers Develop a New Concept for Multi-Path, Direct Current Armature Windings," presented in General Motors Engineering Journal, *Vol.* 4, *No.* 4, *October-November-December,* 1957.

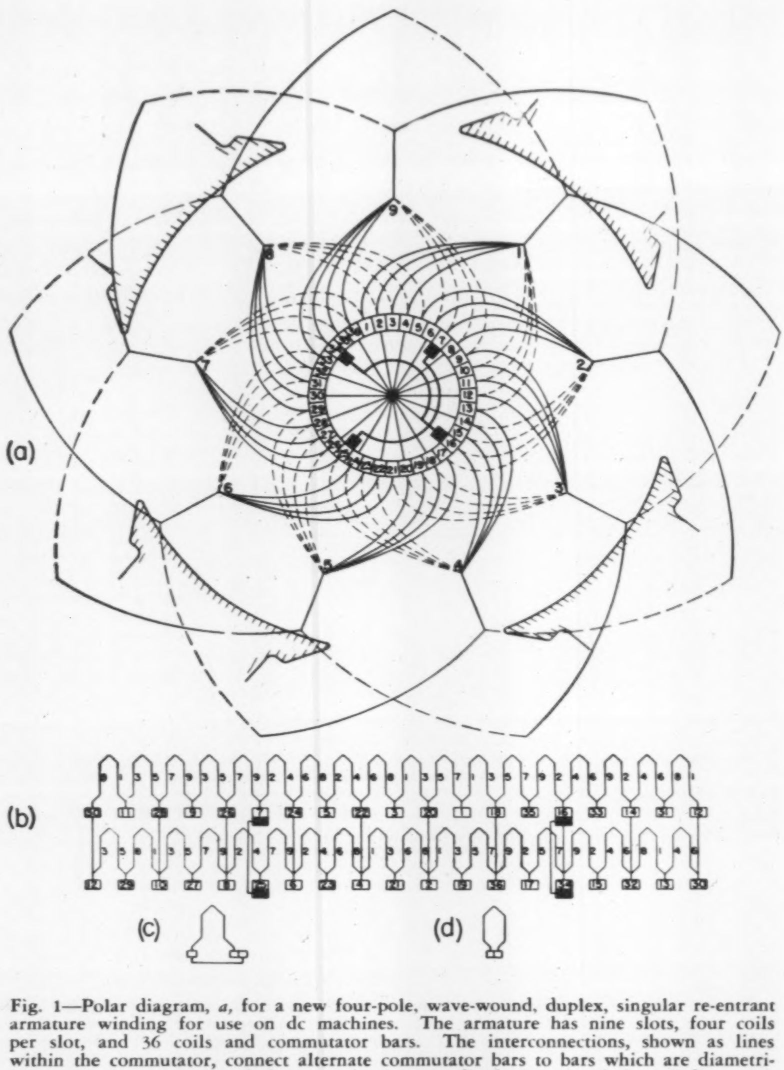


Fig. 1—Polar diagram, *a,* for a new four-pole, wave-wound, duplex, singular re-entrant armature winding for use on dc machines. The armature has nine slots, four coils per slot, and 36 coils and commutator bars. The interconnections, shown as lines within the commutator, connect alternate commutator bars to bars which are diametrically opposite. Developed diagram, *b,* shows individual coils of the winding with associated commutator bars. The two branches for the four parallel paths are disposed one above the other so that the commutator bars are located directly above or below each other. Coil sides are numbered to correspond to the number of slots in which they lie. Interconnections are the vertical lines connecting alternate pairs of commutator bars and join pairs of coils lying in the same slots. Since interconnections are in voltage opposition in the network, there can be no appreciable current flow around the loops or in the entire winding under no-load conditions.

Put strength, long life, silence into gears and couplings with CDF Celoron® molded plastics

WORK MIRACLES IN MACHINERY with this amazing golden phenolic material! Celoron gears help eliminate noise and reduce wear on mating metal gears. Even the roughest-used helicals last . . . and last . . . and last.

HIGH MECHANICAL STRENGTH. Typical Celoron strengths: tensile, 6,500 psi; flexural, 10,000 psi; compressive, 25,000 psi; shear, 8,500 psi. Dimensionally stable and readily machined, Celoron fills the bill where costly metal parts fail.

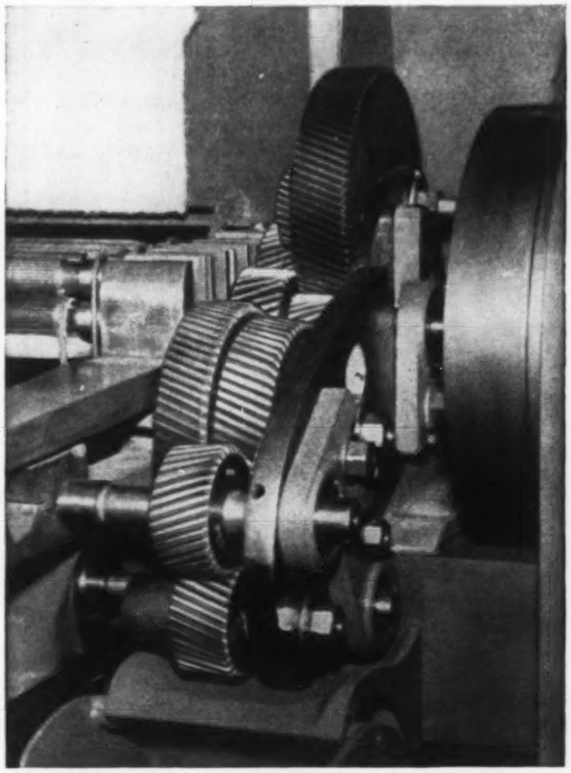
ELECTRICAL INSULATION VALUE. Celoron is a non-conductor with high electrical insulation value. It makes ideal mechanical-electrical parts. Celoron couplings effectively insulate motors from driven machinery.

CDF FABRICATION SERVICE. Let the plastics-fabrication and molding experience of CDF save you time and money, and assure you delivery of production quantities of CDF plastics and molded parts—on time and as specified. The CDF man can help you from the very beginning. See his phone number in the Product Design File (Sweet's). Or send us your print or your problem, and we'll return samples and technical literature for your evaluation.

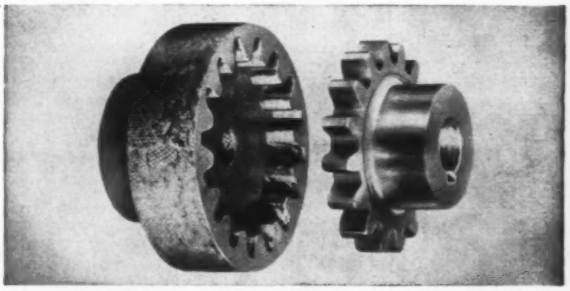
CDF

CONTINENTAL-DIAMOND FIBRE

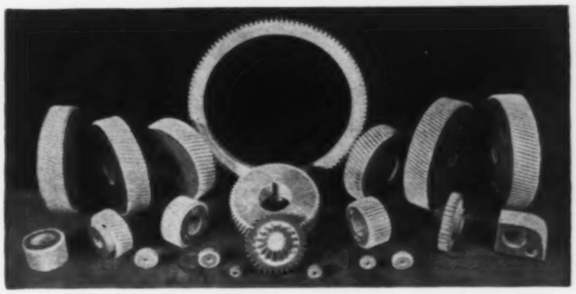
A SUBSIDIARY OF THE Budd COMPANY • NEWARK 23, DEL.



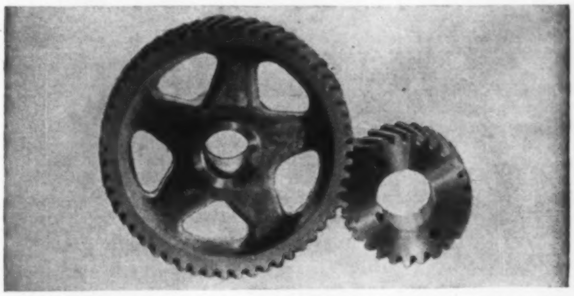
CELORON-TO-CELORON GEARS in drawing rolls made by Ideal Industries, Inc., Bessemer City, N. C. These are helical-cut gears—the toughest to machine, requiring the toughest material. Celoron is it. Other Celoron parts for this application are shown below, top right.



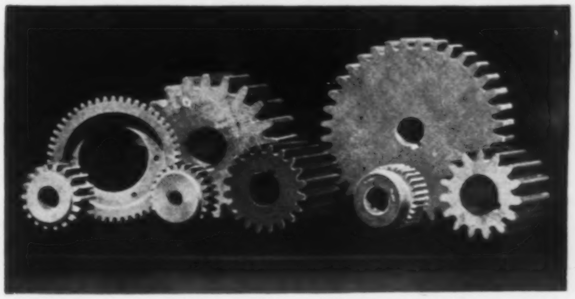
LOW-COST, EASILY-ASSEMBLED CDF Celoron flexible coupling transmits power smoothly, silently . . . insulates motor from machine . . . needs no lubrication . . . works vertically or horizontally.



PRECISELY MACHINED KEYWAYS help keep these Celoron parts silent and strong in the Ideal drawing rolls illustrated in top photograph. Note wide range of sizes and shapes.



CELORON-TO-STEEL combination makes this long-wearing timing mechanism for gasoline engines. Celoron gear absorbs shock, cuts sound to a minimum, holds timing longer.



STRONG, SILENT CELORON makes both drive and driven gears. In fact, many machine applications are 100% Celoron geared for light weight, elimination of excess play, long life.

Circle 491 on Page 19

Helpful Literature

for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card — page 19

Diaphragm Seals

Protection of pressure instruments against corrosion and clogging is assured by using Brookseal diaphragm seals. These units are available for pressures to 2500 psi. Details are given in Bulletin 250. 2 pages. Brooks Rotameter Co., Lansdale, Pa. E

Circle 601 on Page 19

Pigtail Splicing

Just how the Burcap, a compression-installed insulated fixture-type splicing connector, assures permanent pigtail splicing of up to five No. 18 wires is explained in data sheet. 2 pages. Burndy Corp., Norwalk, Conn. B

Circle 602 on Page 19

Lubrication Equipment

Catalog 92 contains detailed descriptions of the complete line of Lincoln lubricant application equipment, such as fittings, guns, centralized systems, and accessories. Lincoln Engineering Co., 5736 Natural Bridge Ave., St. Louis 20, Mo. I

Circle 603 on Page 19

Rotary Compressors

A new line of rotary air compressors is detailed in an illustrated brochure. These 1 to 2-hp pumps supply air in the 150 to 175 psi range. American Brake Shoe Co., 530 Fifth Ave., New York 36, N. Y. D

Circle 604 on Page 19

Brazing Material

Braze-Clad, a brazing aid which makes possible the brazing of complex and blind joints, is subject of illustrated folder. Procedures and typical uses of this material are shown. 4 pages. American Silver Co., 36-07 Prince St., Flushing 54, N. Y. D

Circle 605 on Page 19

Steel Bars

Complete performance and application data on Fatigue-Proof steel bars which have a minimum tensile strength of 140,000 psi and minimum hardness of 30 Rockwell C are contained in booklet entitled "A New Material." 24 pages. LaSalle Steel Co., 1420 150th St., Hammond, Ind. J

Circle 606 on Page 19

Magnetism In Steels

Magnetism of wrought and cast stainless steels and its relation to corrosion resistance is discussed in Data Sheet No. 1. Causes of magnetism are explained. 1 page. Alloy Steel Casting Co., 101 County Line Rd., Southhampton, Pa. E

Circle 607 on Page 19

Drives & Conveyors

"Mechanical Power Transmission and Conveying Machinery" is title of Catalog 610. Listed is the complete line of chain for practically every conceivable power transmission, timing, tension, and conveying application. Two pages of basic selection data aid in choosing the proper chain for any given application. Also described are sprockets, bearings and take-ups, transmission components, elevator buckets, and accessories. Chain Belt Co., Milwaukee 1, Wis. K

Circle 608 on Page 19

Fuse Products

"Cooling fin" Type CK knife blade fuse for 450-600-amp 250-v and 225-600-amp 600-v-service, various renewable fuses, one-time fuses, clip clamps, plug fuses, Fustats, and midget fuses are described and shown in Catalog 48. 8 pages. Monarch Electric Corp., Jamestown, N. Y. F

Circle 609 on Page 19

Panel & Flashlight Lamps

Chart on panel and flashlight lamps lists numerically all lamps made by Chicago Miniature, General Electric, National Carbon, RCA, Raytheon, Tung-Sol, and Westinghouse. Bulb type, base, volts, amps, dimensions, and bead color are given. 4 pages. Radio-Electronic Master, 60 Madison Ave., Hempstead, N. Y. D

Circle 610 on Page 19

Miniature Couplings

Tiny power couplings for servomechanisms, computers, and other devices are described in illustrated Bulletin MC-100. Except for stainless steel set screws, they are made entirely of nonferrous materials. Specifications of available units are given. 4 pages. Thomas Flexible Coupling Co., Warren, Pa. F

Circle 611 on Page 19

Multiple Circuit Switch

Duo-Snap heavy duty multiple circuit switch for machine tool use is subject of Data Sheet DS-1. It has a 230-v, 2-hp or 115 v., 1-hp ac rating. Specifications are given. 2 pages. Robertshaw-Fulton Controls Co., Acro Div., Columbus 16, Ohio. G

Circle 612 on Page 19

Molded Plastic Parts

Stock molded plastic parts, available without tooling charge, are described and illustrated in folder. Included are nuts, many knobs, hand wheels, handles, and agitator caps. 4 pages. Dimco-Gray Co., 207 E. Sixth St., Dayton 2, Ohio. G

Circle 613 on Page 19

Motors

Features of Life-Line electric motors, including 4-way sealed and prelubricated bearing assembly, fortified insulation, die-cast rotor, unitized stator, continuous wound coils, and "armorized" housing, are detailed and illustrated in Bulletin 3000. Totally enclosed models and gearmotors are covered. 24 pages. Westinghouse Electric Corp., Motor & Control Div., Buffalo, N. Y. F

Circle 614 on Page 19

Tubing

Facilities for production of mechanical and aircraft seamless, and electric resistance welded tubing and for fabricating and forging are described in illustrated Bulletin CF-2. Size ranges for various shapes are listed. 14 pages. Copperweld Steel Co., Ohio Seamless Tube Div., Shelby, Ohio. G

Circle 615 on Page 19

Centralized Lubrication

Principles of operation, product advantages, and system components are discussed in Bulletin 26-S on centrallized systems of lubrication. Colored cut-away diagrams show operation. Applications to various pieces of equipment are shown. 20 pages. Farval Corp., 3300 E. 80th St., Cleveland 4, Ohio. F

Circle 616 on Page 19

Packings

Chevron packings for rams, plungers, and reciprocating rods are subject of Catalog AD-115. Materials of construction and recommended uses for various styles are given, as are specifications of each type. Packings for extreme pressures are also detailed. 8 pages. Garlock Packing Co., Palmyra, N. Y. F

Circle 617 on Page 19

Exchangers

Type BCF exchangers with corrosion resistant copper alloy core assembly are detailed in illustrated Bulletin 1.1K6. They are pre-engineered, standardized, and stocked. Cut-away view shows construction, and engineering drawings and tables give specifications. 8 pages. American Radiator & Standard Sanitary Corp., Ross Heat Exchanger Div., Box 2081, Buffalo 5, N. Y. F

Circle 618 on Page 19

Motors

Construction details of Series 254-U rerated motors are shown in colored cut-away views, and are also described in text of Bulletin 520. They can be installed in any environment. 8 pages. Robbins & Myers, Inc., Springfield, Ohio. G

Circle 619 on Page 19

Threaded Tubular Rivets

Data book for designers and engineers presents how-it-works, application, preparation procedures, tool adjustments, and other data on Rivnut internally threaded tubular rivets.

(Advertisement)

New timing motor rated 60 in-oz torque...

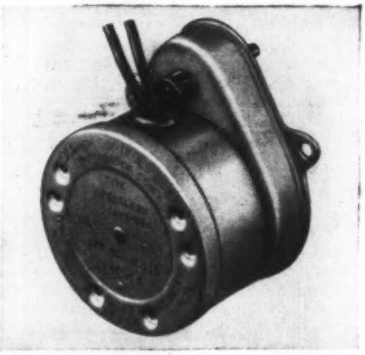
New permanent magnet motor series by Cramer includes "double-strength" and military versions

High torque output, truly synchronous operation, instant starting and stopping, are inherent features of permanent magnet timing motor design. These advantages have been optimized in the new Cramer Type 117, resulting in a motor line with maximum application flexibility.

Five basic versions

Series 117 comes in five basic forms (1) Form P, the standard, highest quality 30 in-oz (at 1 rpm) instrument motor, (2) a militarized version of Form P, (3) Form H, a "double strength" version, (4) Form M, for economy in high volume use, and (5) Form N, a compact, cylindrical gear-train model.

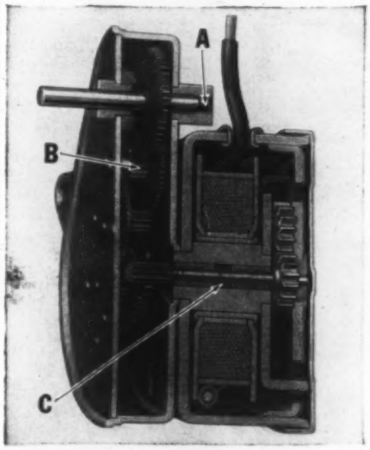
All have these features: instant starting, absolutely synchronous operation, and permanent magnet braking. Coil voltages up to 250V ac, 50 and 60 cycles. Input less than 2.5 watts at rated voltage. Temperature rise only 35°C. Ambient temperature range –20°F to +130°F. Gears all hobbed, with drawn pinion rod. Underwriters' Laboratories approved.



NEW CRAMER TYPE 117 MOTOR. The Type 117 motor, in its several forms, replaces Cramer Types 111, 112, 113, 114 with greatly improved performance.

Standard for quality

The standard version of the Type 117 motor, Form P, is rated 30 in-oz torque at 1 rpm. It's ideal for instruments and industrial control devices requiring field-proved dependability, timing accuracy and longest service life. Oilite rotor bearings, bronze upper and lower output bearings, and a ball thrust bearing backing up the output shaft give exceptional life and performance. A soldered gear cup cover keeps dirt out and lubricant in. Over 100 available speeds from 1 rev. per second to ½ rev. per day.



IMPROVED BEARINGS help double life expectancy of Type 117 motors. Forms P, H feature ball thrust (A) in lower output bearing. All forms boast hobbed gears throughout (B), and Oilite rotor bearings with permanent supply reservoir (C).

Double-strength version, too

Type 117 is offered also in a "double-strength" model, (Form H) rated 60 in-oz at 1 rpm. Applications are in heavy chart recording devices, high speed counters and the like, requiring high torque at fast speeds—as, for example, in the Cramer Type 640E running time meter which reads in 1/10 seconds. Readily available in speeds 60 rpm to 2 rpm. Like the Form P, external finishes are tin and cadmium plate, protected by clear iridite.

A form for economy

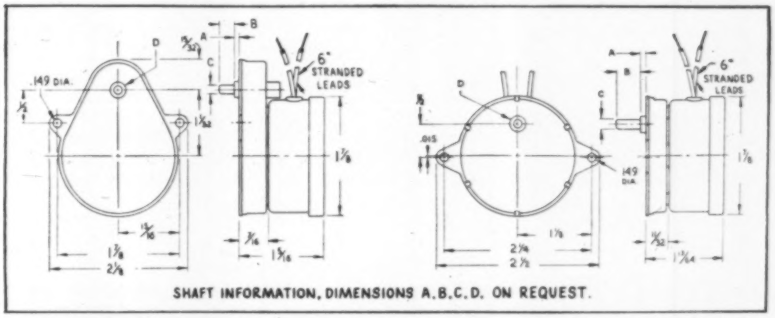
Economy for volume applications is dominant in the Type 117, Form M motor. It has the same torque and wide variety of speeds as the standard industrial version, Form P, above. A few differences: Ball thrust bearing is not used. Gear cover is crimped (instead of soldered) and external finishes are natural brass and black oxide. Advertising displays, appliance timers, vending machines are typical applications.

This one saves space and money

A space-saving cylindrical gear train—same diameter as the basic motor—is the big feature of Form N, Type 117. Basic motor is the same as the economical Form M above. Ideal for limited space applications, Form N is offered in speeds from 60 rpm to 1/12 rpm.

MilSpec model

The militarized version, identified as "Form P, Military," is practically identical with the standard version except for the coil which (here) is vacuum impregnated and supplied with high-temperature rated insulation on the leads. Ambient operating temperature range –55°C to +85°C.



DIMENSIONS: Type 117 motor, Forms P, M and H (left). Form N (right).

Write for complete data on the new Cramer Type 117 motors today. Or better yet, ask your nearest Cramer representative to tell you about them. Cramer Controls Corporation, Box 6, Centerbrook, Connecticut. 7.30

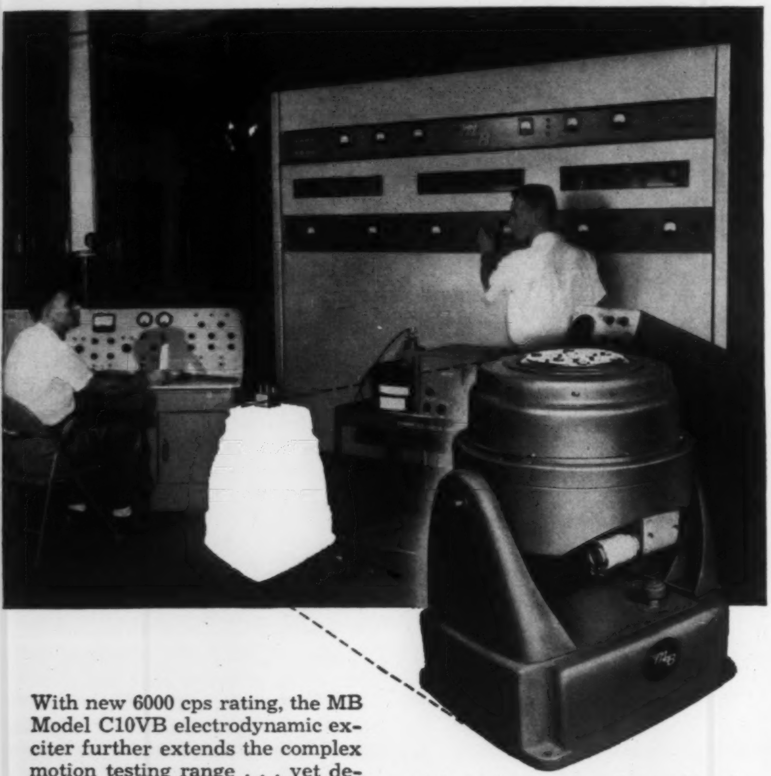
TALK IT OVER WITH

CRAMER CONTROLS
CORPORATION

Circle 492 on Page 19

6000 cps

—a new high in frequency from a high force vibration exciter system



With new 6000 cps rating, the MB Model C10VB electrodynamic exciter further extends the complex motion testing range . . . yet delivers 1750 pounds force for sinusoidal testing with an MB Model T666 15 KVA amplifier (36,000 watt plate dissipation).

This is versatile equipment. With an MB T666 amplifier and TEMC control cabinet, it has the "muscle" to subject electronic products and other critical components to accelerations up to 58 "g". Adding an MB T88 Complex Motion Console equips it for duplicating the actual "noise" or random motion of the environment. This system is designed with an eye to future needs.

What's more, the exciter works in environmental test chambers, so that vibration can be combined with heat, cold, altitude. This not only saves test time, but gives more realistic data on performance as well.

MB C10VB Exciters have UNIMODE rocker suspension (pat. pend.) which assures linear motion and a uniform spring rate over the total stroke of 1-inch (double amplitude).

Users of MB test equipment have at their call a nationwide field service organization of vibration specialists to help on application problems. Send for full data on the complete line MB Shakers.

MB manufacturing company
A DIVISION OF TEXTRON INC.
1056 State Street, New Haven 11, Connecticut
HEADQUARTERS FOR PRODUCTS TO ISOLATE . . . EXCITE . . . AND MEASURE VIBRATION

Circle 493 on Page 19

Various types are described, and specifications and test data are given. Slide-chart type demonstrator shows their fastening principle. 16 pages. B. F. Goodrich Co., B. F. Goodrich Aviation Products Div., Akron, Ohio. F

Circle 620 on Page 19

Special Motors

"When to Specify Special Motors" is title of a 24-page booklet which outlines the factors in deciding whether a modified standard or custom-designed motor is practical and economical for a particular product design. It is a reprint of a MACHINE DESIGN article. 24 pages. Jack & Heintz, Inc., Cleveland 1, Ohio. F

Circle 621 on Page 19

Conveyor Chain & Sprockets

Flat-Veyor chain and sprockets are illustrated and their specifications given on Data Sheet CD-103-A. Electrolized or black chain is offered in 3¼ to 7½-in. widths, with companion sprockets. 1 page. Browning Mfg. Co., Maysville, Ky. G

Circle 622 on Page 19

Solid Film Lubricant

Technical details of No. 4396 high load-carrying, solid film lubricant are given in Bulletin 2049. It has good adhesion characteristics, abrasion resistance, and resiliency under load. Properties and wear life are detailed. 4 pages. Electrofilm, Inc., Box 106, North Hollywood, Calif. L

Circle 623 on Page 19

Rectifier Stacks

Forward voltage drop of less than 1 v per cell, operating temperatures from −65 to 170° F, and efficiencies up to 99 per cent are among features of silicon rectifier stacks outlined in illustrated Catalog ECG-213. How to build a stack is described. Specifications of available units are given. 6 pages. General Electric Co., Semiconductor Products Dept., Syracuse 1, N. Y. C

Circle 624 on Page 19

Ball Bearing Yield

"Ball Bearing Yield and System Isoelasticity" is an illustrated booklet which will assist users in the application of precision instrument bearings. Radial and axial play, axial take-up and preloading, and the achievement of system isoelasticity are covered. 12 pages. Barden Corp., Danbury, Conn. B

Circle 625 on Page 19

Roller Chains

Prices for standard attachments for standard and double-pitch roller chains are given in illustrated Bulletin 507. American Standard and Diamond Chain numbers are given for each type and size. 8 pages. Diamond Chain Co., 402 Kentucky Ave., Indianapolis 7, Ind. J

Circle 626 on Page 19

Electric Motors

How close coupling of electric motors with machined seal cavities to pumps reduces weight, minimizes parts inventory, and assures alignment is illustrated in Folder P 86013. Uniseal motors described are appli-

Streaking through the air faster than speed of sound, the B-58 Hustler depends upon nickel-containing stainless steel to withstand the tremendous heat developed by engine exhausts. B-58 is built by Convair, a division of General Dynamics Corporation.

How a nickel-containing stainless steel keeps Hustler from being "skinned alive"

At the speed the Hustler flies, heat from air friction is a problem.

Where this heat is amplified by heat from the powerful jet engines, the plane's skin could overheat dangerously . . . lose strength.

Convair engineers overcome this by cladding portions of the Hustler exposed to the exhaust blast with "honeycomb sandwich" panels made of a special nickel-containing stainless steel. Thin ribbons of stainless steel are formed into a honeycomb shape which is then sandwiched between two thin sheets of stainless steel.

They use 17-7PH stainless steel, produced by Armco Steel Corporation, because it has five times the yield strength of low carbon steel, and it retains much of its strength even at 900°F.

17-7PH stainless steel honeycombs provide the high strength, stiffness, and low weight needed by the Hustler as it outspeeds sound, 50,000 feet above the earth.

Does some metal problem face your staff?

Is it a problem that involves heat, cold, corrosion, wear, stresses, fatigue? Or is there some other obstacle? There's better than a fair chance we can help your engineers get off the ground. Or at least work with them to trim the problem down to manageable size. Suggest that they send for a copy of "Stainless Steel in Product Design" and an Inco analysis sheet that will help them define the problem.

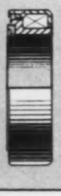
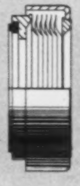
THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

INCO

INCO NICKEL

NICKEL ALLOYS PERFORM BETTER LONGER

WHICH SEAL WILL SOLVE YOUR PROBLEM?

Seals drawn to same scale.				
Type of Seal	**Standard**	**Modified**	**Bellows**	**Shaft Surface**
Pressure (PSI)	1000	500	250	75
Speed (FPM)	15,000	15,000	15,000	15,000
Temperature (°F)	350° to 450°	−360° to 350°	−360° to 700°	500° to 700°
Uses	Fluids including aviation fuel, synthetic lubricants, etc.	Rocket motors, HNO_3, H_2O_2, NPN, LOX, Ethylene Oxide	Applications calling for all-metal, high temperature sealing	Sealing gaseous mediums in a minimum amount of axial space
Send for	Bulletin #7	Specially engineered	Bulletin #18	Bulletin #19

CAUTION: Maximum conditions indicated for each type do not necessarily imply that all are available in a single seal. Sealol engineers will gladly recommend the seal best suited to the operating conditions of your particular application. Write today . . . no obligation, of course!

SEALOL CORP **342 Post Rd., Providence 5, R. I.**

SEALOL

Please send me Sealol Bulletins checked below.

☐ Bulletin #7—Standard Seals
☐ Bulletin #18—Bellows Seals
☐ Bulletin #19—Shaft Surface Seals
☐ Contact us regarding a special application

Name .... *Title* ....
Company ....
Street ....
City .... *State* ....

Circle 495 on Page 19

cable to many electrically powered devices. 4 pages. Franklin Electric Co., Bluffton, Ind. J

Circle 627 on Page 19

Printed Circuit Receptacle

The MS receptacle, designed to mate with from one to four printed circuit boards, is available in both pin and socket assemblies. Data provided by bulletin include dimensions and current tooling. 1 page. Cannon Electric Co., Pingree & Leavitt Sts., Salem, Mass. L

Circle 628 on Page 19

Lubricant System

Complete design, application, and operating data on the Alemite Accumite centralized lubrication system for built-in measured lubrication of all bearing or friction points in machines are given in Engineering Guide 34-28. This low cost, midget size, positive displacement system is readily installed. 36 pages. Stewart-Warner Corp., Alemite Div., Chicago 14, Ill. J

Circle 629 on Page 19

Plastic Extrusions

Rods, shapes, strips, tubes, and tape are some of the forms of plastic extrusions described in illustrated bulletin. Also covered is service for continuous plastic coating of "hard-to-coat" materials. 4 pages. Pyramid Plastics, Inc., 554 W. Polk St., Chicago 7, Ill. I

Circle 630 on Page 19

Shaft Retention Fasteners

Just how the pilot tooth design of new Fastex Springrip fasteners simplifies their installation on shafts is explained in Bulletin AF-9. Also covered are other shaft retention fasteners such as vinyl Plasti-Ring shaft retainers, Push-On fasteners, and C-Ring washers. 8 pages. Illinois Tool Works, Fastex Div., 195 Algonquin Rd., Des Plaines, Ill. J

Circle 631 on Page 19

Plug-in Limit Switch

Replaceable in seconds, the new Micro Switch plug-in limit switch is offered in five actuator types and is adaptable for 24 different mounting arrangements. This two-circuit double-throw control is rated 10 amp on 120, 240, or 480 v ac. Ask for Bulletin 20. 4 pages. Minneapolis Honeywell Regulator Co., Micro Switch Div., Freeport, Ill. K

Circle 632 on Page 19

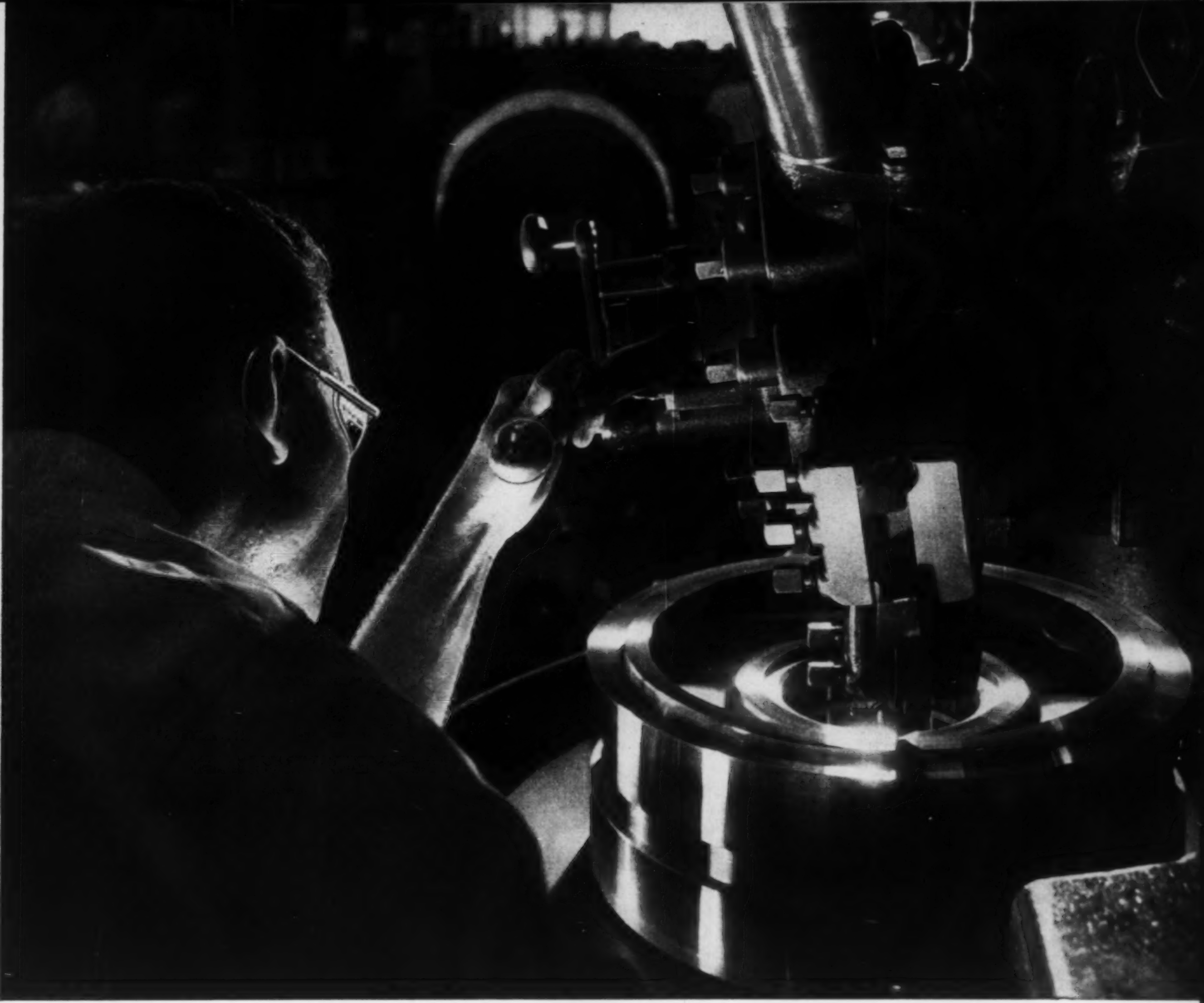
Hydraulic Packings

Recommended leather, homogeneous rubber, and fabricated rubber V-packings for use under various service conditions are given in Bulletin 2-31 on Vix-Syn V-packings. Standard sizes are listed. 4 pages. E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa. C

Circle 633 on Page 19

Relief Valves

Two models of adjustable, spring-actuated relief valves, each available in six sizes, with adjustable pressure ranges of 5 to 35 psi and 35 to 100 psi are described in Catalog 110. Valves can be used with rotary pumps in complete liquid control sys-



From a Sound Blank Comes a Sound Finished Product

One of the best ways to insure top quality in finished circular products is to insist on sound, reliable blanks. You have this assurance when your specifications call for Bethlehem blanks, which are unsurpassed anywhere.

These sturdy steel pieces are made in a two-way mill that combines the steps of forging and rolling. Blanks produced in this mill have uniformity and good grain flow. They are very strong; hence thinner sections can often be used. And their internal structure is so dependable that machining can be done with confidence. There is no hidden trouble lurking beneath the surface of the metal.

Bethlehem forged-and-rolled blanks are widely used in the making of gears, crane and industrial wheels, sheave wheels, flywheels, brake drums, turbine rotors, pipe flanges, and other circular products. They are available in a wide range of sections, and in sizes from 10 to 46 in. OD. Orders can be furnished heat-treated or untreated.

We suggest you get full details from the nearest Bethlehem office. Or write for a copy of Booklet 216, which contains many interesting facts and more than 80 photographs.

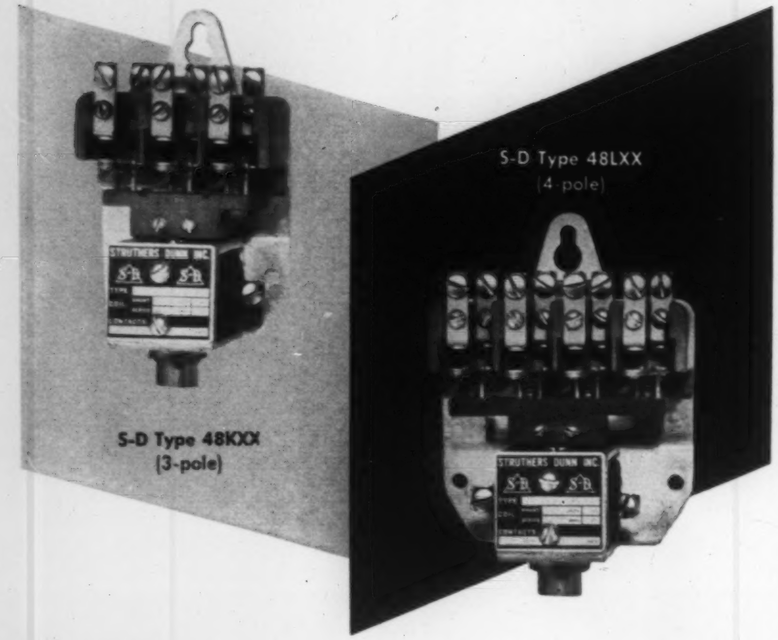
BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by
Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

Circle 496 on Page 19



Small Size . . . Long Life . . .

ECONOMY CONTACTORS

for motor control applications

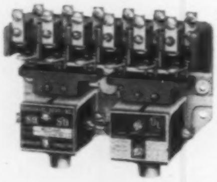
Backed by full Struthers-Dunn quality, designed to minimum size consistent with dependable performance, these new 3- and 4-pole AC contactors are ideally suited for "built-in" control of AC motors, solenoids, valves, lamps, heaters and other loads.

Contacts are conservatively rated at 15 amperes to 600 volts AC and with horsepower ratings to 3 h.p. for 440/550-volt service AC 3-phase.

Struthers-Dunn Data Bulletin 7048 will bring you full details.

REVERSING TYPE

S-D Type 175KXX includes two durable solenoids each opening three double-break, normally-open contacts. Ratings are similar to above. Write for S-D Data Bulletin 7100.



STRUTHERS-DUNN, Inc.
Pitman, N. J.

5,348 Relay Types...World's most diversified relay selection

Sales Engineering Offices in: Atlanta • Boston • Buffalo • Chicago • Cincinnati Cleveland • Dallas • Dayton • Detroit • Kansas City • Los Angeles • Montreal • New Orleans • New York • Pittsburgh • St. Louis • San Francisco • Seattle • Toronto

tems. Tuthill Pump Co., 939 E. 95th St., Chicago 19, Ill. J

Circle 634 on Page 19

Alloy Temperature Ranges

In addition to alloy temperature range chart, Bulletin 106 gives physical and mechanical properties of Type 321 high temperature 18/8 alloy used for 1000 to 1600° F operating temperatures. 2 pages. Rolled Alloys, Inc., 4815 Bellevue, Detroit 7, Mich.

Circle 635 on Page 19

Large Induction Motor

Details presented in Bulletin 1950 cover line of induction motors in ratings from 150 to 1250 hp. Motors are used in process machinery and industrial compressors, pumps, mixers, crushers, and impact breakers. 16 pages. Louis Allis Co., 427 E. Stewart St., Milwaukee 1, Wis. K

Circle 636 on Page 19

Vacuum Breaker

Cash-Acme type VB antisiphon vacuum breakers prevent polluted water from back siphoning into a potable water supply line. Details of ⅜ to 2-in. sizes of these valves are given in Bulletin 5-2. 2 pages. A. W. Cash Valve Mfg. Co., Decatur, Ill. I

Circle 637 on Page 19

Filters & Capacitors

Features and design innovations in new line of miniaturized radio frequency filters and capacitors are outlined in Bulletin 57B. They make possible the design of electrical and electronic components with minimum weight and bulk. 4 pages. Airborne Accessories Corp., 1414 Chestnut Ave., Hillside 5, N. J. D

Circle 638 on Page 19

Drafting Tables

Designed to complement the decor of modern offices and plants, Ancosteel and Ancowood drafting tables are fully described in two brochures. Both types are durable and readily adjusted. 4 pages each. Anco Wood Specialties, Inc., Glendale 27, L. I., N. Y. D

Circle 639 on Page 19

Ductile Iron

"Ductile Iron Digest" is title of guide and case study handbook on a new metal that has up to 200,000-psi tensile strength. It can be twisted and bent without cracking, and has as much as 30 per cent elongation. 18 pages. International Nickel Co., 67 Wall St., New York 5, N. Y. C

Circle 640 on Page 19

Fasteners

Offered as guidance for users and specifiers of fasteners, 1958 catalog gives complete specifications on nuts, bolts, screws, lock washers, and hundreds of other fasteners. Also described are company's stamping, cold-heading, and screw machine products facilities. 40 pages. Abbott Screw & Bolt Co., 1728 W. Walnut St., Chicago 12, Ill. J

Circle 641 on Page 19

Vibrationproof Switch

Reduction in operating noise level is accomplished in line of remote control switches by soundproof enclosures

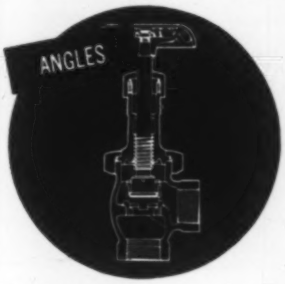
Circle 497 on Page 19

IF YOUR PRODUCT IS VALVE-EQUIPPED— JENKINS VALVES WILL ADD AN

Extra Sales Feature

PACKAGE BOILERS • FIRE FIGHTING APPARATUS

LAUNDRY EQUIPMENT • DISH-WASHING MACHINES



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RAPID ACTION GATES

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You get the extra sales advantage of Jenkins famous Diamond and Signature trademark which identifies each valve.

-and here's how YOU SAVE TIME AND TROUBLE

You profit by Jenkins long experience in supplying valves for all types of products.

You add the valve know-how of Jenkins Engineers to your own designing skill. Modifications of standard valves, such as special handwheels, etc., can be provided when required. Send coupon today for information.

Give your product, and its purchasers, the *extra value* of Jenkins Valves . . . *it costs no more.* Jenkins Bros., 100 Park Ave., New York 17.

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SINCE 1864
TRADE JENKINS MARK
Jenkins Bros

JENKINS BROS., 100 Park Ave., New York

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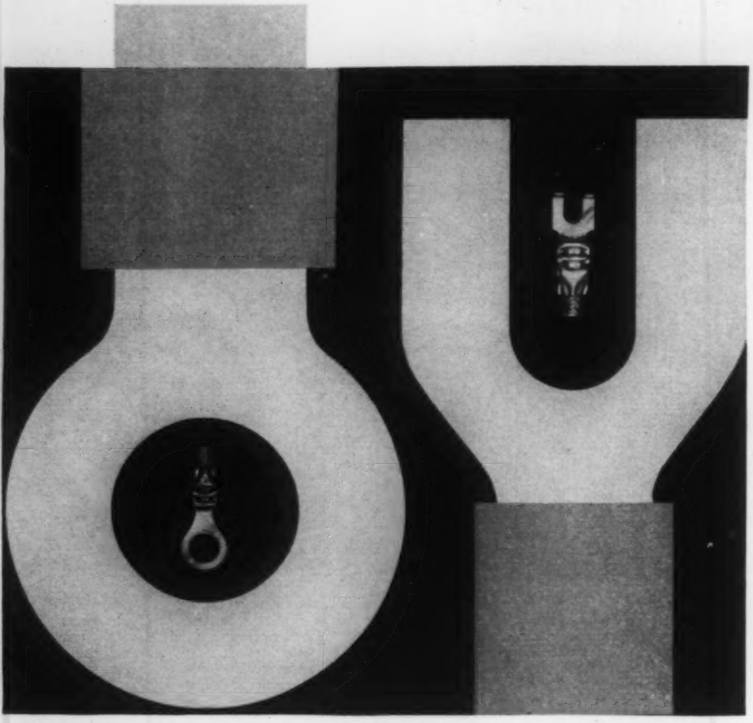
Circle 498 on Page 19



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faster . . . specify the A-MP® PRE-INSULATED DIAMOND GRIP terminal

If you need terminals with bonded insulation—if you need corrosion resistance and wire-supporting vibration resistance—you have it instantly in one closure of A-MP's matched crimping tool. Only one lightning-quick step for crimp-sure optimum strength and conductivity. A-MP PRE-INSULATED DIAMOND GRIP Terminals exceed the most rigid military and commercial specifications.

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To solve your wire-end problems, we maintain an international engineering service.

For the full story on the A-MP PRE-INSULATED DIAMOND GRIP line, send for our catalog.

AMP INCORPORATED
General Offices: Harrisburg, Pennsylvania
A-MP products and engineering assistance are available through wholly-owned subsidiaries in: Canada • England • France • Holland • Japan

Circle 499 on Page 19

and vibration mounts described in Bulletin 627. Switches are used for control of power and lighting circuits. 2 pages. Automatic Switch Co., Florham Park, N. J. D

Circle 642 on Page 19

High Strength Bolts

Designed for engine and airframe applications, NAS 624-644 Series high strength, 12-point, external wrenching, aircraft bolts are detailed in Form 2320. Full specs are given. 8 pages. Standard Pressed Steel Co., Jenkintown, Pa. C

Circle 643 on Page 19

Data Logger

Building-block construction and flexible pinboard programming are features of the new Series 1200 Data Logger described in Catalog 30A1200. It accepts up to 200 or 2000 inputs, makes conversions to dc voltages and performs zero offset, scaling, and characterizing of nonlinear inputs. 6 pages. Fischer & Porter Co., 464 Jacksonville Rd., Hatboro, Pa. E

Circle 644 on Page 19

High Fidelity Cabinets

Entitled "Cabinart '58," color-illustrated catalog shows a wide range of high fidelity equipment cabinets and speaker enclosures. Available finishes and other information are presented. G & H Wood Products Co., 99 N. 11th St., Brooklyn 11, N. Y. D

Circle 645 on Page 19

Vibration & Shock Control

How to control vibration, shock, and noise in massive, difficult-to-isolate machinery is explained in Bulletin VC-501. Properties and performance data are presented on Armstrong Vibracork. This granular structure material has millions of sealed air cells which "float" the load and dampen noise. 2 pages. Korfund Co., 48-19D 32nd Place, Long Island City 1, N. Y. D

Circle 646 on Page 19

Vacuum Metallizing

Vacuum metallizing or vacuum plating is a clean, low cost, production technique for producing a bright, lustrous, metallic finish on metal, plastic, glass, paper, or textiles. Full details of this process, as well as its applications in the design field are related in Catalog 780. Vacuum metallizing equipment is described also. F. J. Stokes Corp., 5500 Tabor Rd., Philadelphia 20, Pa. E

Circle 647 on Page 19

Systems Manufacturing

"On Target" is title of booklet which shows how this company meets the requirements in manufacturing military weapon sub-systems and components. Machinery, quality control, and assembly operations are pictured. 12 pages. Servo Corp. of America, 20-20 Jericho Turnpike, New Hyde Park, N. Y. D

Circle 648 on Page 19

Plastic Blower Wheel

Performance data on Desco one-piece molded plastic blower wheel when operating at 1050, 1140, 1500, and 1725 rpm are given in Form 53-55. Wheel features aerodynamically

RB&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

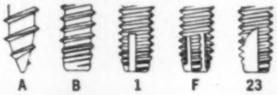
Technical-ities

By John S. Davey

How to select tapping screws

1. Use *thread forming* screw Type A, B or C when material is ductile enough to stand deforming action of screw. If not, use *thread cutting* type.

2. Type A is used with pierced hole for starting; and where an exposed point doesn't matter. All other cases use B, C, or other blunt screws in drilled holes.



3. When load is no factor, metal gauge determines diameter of screw. Pick a thread pitch which gives at least a full thread engagement.

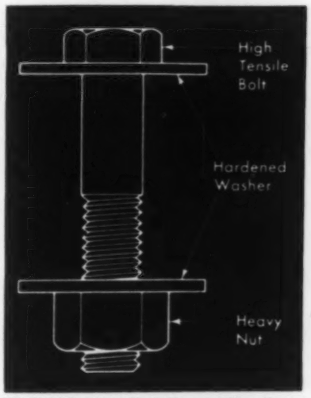
FOR EXAMPLE: Metal .062" thick suggests use of #7 Type A or #10 Type B (both have 16 threads/inch).

$$\text{PITCH}=\frac{1.00}{16}=.0625''$$

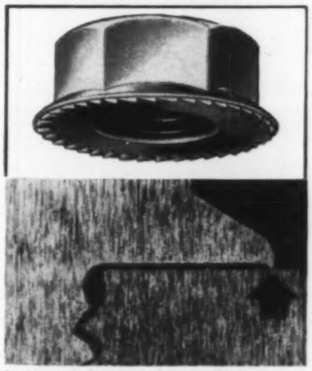
4. When you do have loads to sustain, you must consider required holding power. If metal thickness doesn't allow ample thread engagement (so that threads strip), use more smaller diameter screws. They engage more threads. Limiting factors: the screw's torsional strength, and the effort to drive it.

5. If, due to material thickness, screws fail by torsion or drive too hard, select cutting screws (1, F, or 23). For hard ductile materials, the Type 1 is best; for soft, friable materials, the Type 23.

Two basic ways to keep fasteners tight



RB&W high strength bolts permit optimum tightening without crushing surface when used with hardened washer.



Section of Spin-Lock screw. Teeth embed only with proper tightening. Same feature available in nuts.

Fasteners that stay tight keep joints strong. Resistance to loosening depends largely upon: (1) The inherent "locking" ability, (2) The man with the wrench.

HIGH PRELOADING

With rigid type joints, one of the best "locking" fasteners is a standard RB&W high strength bolt or cap screw . . . *torqued up close to its yield strength.* It locks by its own internal residual tension.

High tension not only keeps it permanently tight, but also prevents fatigue, assures optimum load capacity and safety.

INTEGRAL LOCKING DEVICE

Suppose the design of fastened members can't take full advantage of such preloading? Then a lock is needed, such as that furnished by RB&W Spin-Lock® screws and nuts. Ratchet-action teeth bite into seat; require 20% extra torque to loosen.

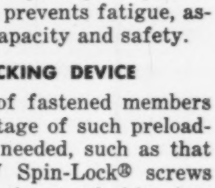
Note that Spin-Lock fasteners seat solidly before locking. The installer can't be deceived. He *has* to tighten properly before feeling resistance.

In both cases above, *positive* tightening assures positive fastening.

Send for Bulletin on Spin-Lock fasteners, or call your local RB&W Fastener Man. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

Plants at: Port Chester, N.Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

Staked acorn nuts lock securely



Staking opposite sides of these RB&W acorn nuts deforms threads for a positive grip. It also puts middle of nut slightly out-of-round, for a spring tension locking effect. They're designed for applications such as outdoor furniture, where anchoring fasteners is more important than solid seating. Available in aluminum, steel, silicon bronze.

These all-metal nuts can also be furnished in regular double chamfered style. Since they lock with their middle threads, they can be turned onto screw from *either* side.

Circle 500 on Page 19

shuts off both sides of line... prevents loss of liquid, gas, or pressure.
Available in brass or steel with female pipe thread connections from ⅛" to 1"
FOR PRESSURE OR VACUUM SERVICE

HANSEN QUICK-CONNECTIVE TWO-WAY SHUT-OFF COUPLINGS

- Both ends of fluid line circuits are positively sealed when you disconnect a Hansen Series HK Two-Way Shut-Off Coupling. To connect, just pull back sleeve and push Plug into Socket. To disconnect, merely pull back sleeve. No tools required. Identical valves in Socket and Plug permit free flow of gas or liquid when Coupling is connected—practically eliminate spilling of liquid or escape of gas when disconnected.

WRITE FOR THE HANSEN CATALOG

Here's an always ready reference when you want information on couplings in a hurry. Lists complete range of sizes of Hansen One-Way Shut-Off, Two-Way Shut-Off, and Straight-Through Couplings—including Special Service Couplings for Steam, Oxygen, Acetylene, etc.

REPRESENTATIVES IN PRINCIPAL CITIES

SINCE 1915 QUICK-CONNECTIVE FLUID LINE COUPLINGS
THE HANSEN MANUFACTURING COMPANY
4031 WEST 150th STREET • CLEVELAND 11, OHIO

Circle 501 on Page 19

designed vanes for quiet operation. 4 pages. Denbo Engineering & Sales Co., 3301 Martindale Ave., Indianapolis 18, Ind. J

Circle 649 on Page 19

Switch Terminology

Standard definitions for snap-acting switches recently adopted by NEMA are given and parts shown in folder entitled "NEMA Standards." 4 pages. Hetherington, Inc., Folcroft, Pa. E

Circle 650 on Page 19

Nickel-Chromium Castings

The complete story of Ni-Hard nickel-chromium white iron castings is told in Bulletin 263 which describes company facilities for pattern making, casting, and quality control. Physical and chemical characteristics, plus a conversion chart for comparing hardness figures are featured. 16 pages. Nordberg Mfg. Co., Milwaukee 1, Wis. K

Circle 651 on Page 19

Counting Devices

Extract of Catalog 57 describes hand speed indicators and revolution, stroke, measuring, predetermining, electromagnetic, and printing counting devices. Speed and other specifications are given for each model. 18 pages. Presin Co., 12128 W. Pico Blvd., Los Angeles 64, Calif. L

Circle 652 on Page 19

Flow Meters

A hard paper disc, eyeletted on the inside cover of Bulletin 110 indicates pressure and temperature limitations of Brooks Rotameters, as well as their flow capacity ranges. Brief description is given on opposite page. Bulletin aids in selection of the right meter for a specific job. 4 pages. Brooks Rotameter Co., Lansdale, Pa. E

Circle 653 on Page 19

Four-way Hydraulic Valves

Pipe connected, flange connected, and sub-plate mounted four-way hydraulic valves operated by lever, cam, or foot are covered in Catalog Section 210. Valves are offered in seven spool designs and eight sizes from ¼ to 2 in. They are rated 2000 and 3000 psi. 12 pages. Rivett Inc., Brighton 35, Boston, Mass. B

Circle 654 on Page 19

Electronic Comparator

Quick, accurate, on-the-job gaging to within 0.00002 in. is possible with the S. I. electronic comparator. Unit consists of steel tipped gaging head and amplifier unit which records movement on dial. Specifications and other details pertinent to the comparator are given in Form T250. 8 pages. Threadwell Tap & Die Co., Greenfield, Mass. B

Circle 655 on Page 19

Variable Speed Drives

Infinitely variable speed drives producing increased torques at either maximum or minimum speed are subject of Bulletin 550. Also presented are systems for automatic control of speed in adjustable proportion to 3-15 psi air signals, 0.5 to 5 ma signals, or control signals from a pneumatic or electrical transducer. 12

TOOLING FOR COMPETITION

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SEE all the very latest advances and improvements in more than thirty major categories of industrial products.

It's the year's most notable industrial event . . . it's your chance to see tooling's future, *your* future on display. See thousands of products, hundreds of demonstrations, presented by 487 exhibitors. Don't miss it! Plan *now* to attend.

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INSPECT the modern equipment and up-to-the-minute manufacturing methods being utilized in booming Delaware Valley plants.

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Circle 502 on Page 19

NEW CLUTCH
Stearns MODEL GS
SMOOTH, INSTANT ACTION
QUIET, COOL RUNNING
NEW COMPACTNESS
TORQUE RANGE 9 TO 540 LB FT
NEW SIMPLICITY
EASY INSTALLATION
LOW MAINTENANCE, LONG LIFE
WET OR DRY TYPES
FAST, POSITIVE ADJUSTMENT
PLUG IN ELECTRICAL CONNECTIONS
(No slip-rings, no brushes)

Save — up to 41% on space
— up to 33% on installed cost

Here's a new concept in electro-magnetic clutches that add an even greater range of application to the already comprehensive Stearns line of over 100 standard clutch and clutch-brake combinations. Stearns can serve your needs on equipment ranging from business machines to ball mills — and larger . . . will also custom-design units to your specific requirements.

For complete data on the new "GS" line, call your local Stearns representative . . . or write for Bulletin 503F. 26

BRAKES MILWAUKEE Stearns WISCONSIN CLUTCHES
ELECTRIC CORPORATION
120 NORTH BROADWAY • MILWAUKEE 2, WISCONSIN

Circle 503 on Page 19

pages. Graham Transmissions Inc., Menomonee Falls, Wis. K

Circle 656 on Page 19

Flow Meters

Engineering data on differential pressure flow meters given in Bulletin F1607 includes basic information and theory on selection, sizing, and installation of the various types of primary devices. Installation practices for gas, liquids, and steam are explained. 22 pages. Bristol Co., Waterbury, Conn. B

Circle 657 on Page 19

Temperature Control

"Got a Temperature Control Problem?" is title of Bulletin MC-157 which tells how Thermoswitch controls help equipment to run at faster speeds, require less maintenance, and have longer life and reduced assembly costs. Six design configurations are given. 4 pages. Fenwal Inc., Ashland, Mass. B

Circle 658 on Page 19

Drill Jig Bushings

Catalog 35875 on A.S.A. and Ex-Cell-O standard drill jig bushings also incorporates aircraft type bushings, a 5/32 in. OD group of press-fit bushings with holes as small as 0.0152 in., and new ½ in. long head and headless press-fit bushings. Ex-Cell-O Corp., 1200 Oakman Blvd., Detroit 32, Mich. H

Circle 659 on Page 19

Stabilized Amplifier

Universal Stabilized Amplifier described in Bulletin USA-3 enables user to obtain output characteristic best suited to application by incorporating the appropriate feedback circuitry. Bulletin gives application diagrams, specifications, and block and circuit diagrams. 2 pages. George A. Philbrick Researches, Inc., 230 Congress St., Boston 10, Mass. B

Circle 660 on Page 19

Power Resistor Decade Box

Clarostat power resistor decade box provides a power resistor of any known value from 1 to 999,999 ohms, merely by twisting six dials. Details of this electronic-electrical instrument are provided in descriptive bulletin. 4 pages. Clarostat Mfg. Co., Dover, N. H. B

Circle 661 on Page 19

Gear Production Facilities

Facilities for production of gears and the various types of gears produced are described in catalog. Company handles all phases of gear manufacture and assembly for a variety of industries. 30 pages. Request on company letterhead from Advance Gear & Machine Corp., 5851 Holmes Ave., Los Angeles 1, Calif. L

Potentiometer Selector

Factual data on case materials, mountings, bearings, ganging, housing, resistance, power, linearity, resolution, rotation, and winding appear in window cutouts of large plastic-coated circular selector chart on line of precision potentiometers. Write on company letterhead to DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y. C

Any similarity to a real-life company is purely intentional

How do they keep their cotton-pickin' fingers clean in Cincinnati?

The folks at the Fluffy Stuff Company like any color as long as it's *white.*

When they celebrate, they paint the town white. When they do most anything, they do it up white . . . to the hilt. They have a white complex. It figures, though. They process cotton. And to be acceptable, their products must have the hue of a polar bear in a snowstorm.

So all was consternation one day, let us tell you, when rust-stains were found on some cotton batting! The air turned blue. Faces became red.

And a search was started to find the culprit. Everybody joined the posse.

Turned out it was a semi-steel spider ratchet in a machine for drying and breaking-up matted cotton batting. It not only deposited, you'll pardon the expression, rust — but some of its spokes or fingers were broken to boot.

But all was not lost. Seems like one of Fluffy Stuff's maintenance men had heard about Ampco Metal, a whole series of special copper-base alloys. (Read some of our ads, we hope.)

At any rate — to make a long story short — the company investigated Ampco Metal. Thought it looked like it had possibilities. Tried it.

At last report, Ampco Metal had not only provided freedom from rust — but it actually had lasted five times longer than the previous part!

But that's not all of the story. Fluffy Stuff was also having trouble with a brass rake used to dig up wet cotton as it passed through a washing machine. The rake had fingers 8″ long x 1″ wide x ½″ thick.

F. S. had a replacement made of Ampco Metal — and it lengthened the life of the rake fingers by 20 times!

Now maybe you make conveyors or condensers, instead of cotton products. But if wear or corrosion are factors to be concerned with, you should look into Ampco Metal. There's an Ampco field engineer nearby who's ready to focus his attention on your particular problems. Call him.

And write for Bulletin 33. *Ampco Metal, Inc., Dept. MD-2, Milwaukee 46, Wis. (West Coast Plant: Burbank, Calif.).*

AMPCO

AMPCO® METAL

The metal without an equal

G-9

Circle 504 on Page 19

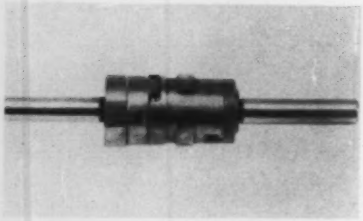
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Indexing Clutch

has fast triggering and high shaft speeds

Dykor Model S-100 clutch uses wrapping principle of a helical-wound coil to give precise indexing and high torque transmission in short response time. Unit is designed for high-speed precision indexing in such applications as stepping devices for tape in electronic computers, one-revolution positioning in instrument and automatic machinery, and photographic sequencing. High shaft speeds and fast triggering are possible because of low-inertia parts. Triggering torque of 0.05 lb-in. engages clutch in 1 millisec to transmit at least 10 lb-in. torque. Angular increments of one or one-half revolution are standard. Clutch body has diam of 17/32 in. and length of 1.007 in. **Digitronics Corp.,** Albertson Ave., Albertson, L. I., N. Y. D

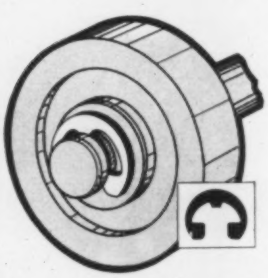


Circle 662 on Page 19

Retaining Ring

reinforced E-ring is radially installed

Truarc Series 5144 retaining ring is designed for use in assemblies in which ring is subject to strong push-out forces resulting from heavy vibration and shock loads, high rotational speeds, or relative rotation between retained parts. It can be used with abutting retained parts having large corner radii or chamfers. Fastener has a heavy web section with tapered, bending arms, permitting greater spring pressure with no increase in permanent set. Entrance gap has been narrowed and inside of lugs made parallel at the gap to further increase gripping power. Unit permits approximately 50 per cent higher rpm limits in most ring sizes as compared with conventional E-ring. Sizes accommodate shaft diameters from 3/32 to 7/16 in. Standard material is carbon spring steel. **Waldes Kohinoor Inc.,** 47-16 Austel Place, Long Island City 1, N. Y. C

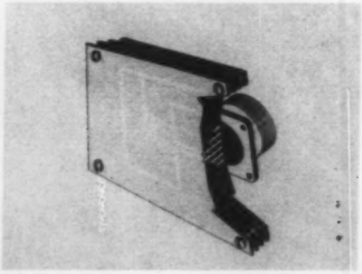


Circle 663 on Page 19

Printed-Circuit Receptacle

mates with one to four printed-circuit boards

MS-type printed-circuit receptacle, designated CA 0186, has special pins made in various lengths at the terminal end. Receptacle mates with from one to four printed-circuit boards. It is available in both pin and socket assemblies, and mates with all MS-type plugs. **Cannon Electric Co.,** 3208 Humboldt St., Los Angeles 31, Calif. L

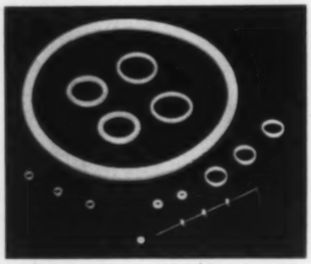


Circle 664 on Page 19

O and V-Ring Seals

in sizes from 3/32 to 15/16 in. OD

Teflon O and V-ring chemical and mechanical seals have dimensional tolerances of 0.001 in. and less. They are available for extreme temperature, pressure, and corrosive applications in the chemical processing, aircraft, electrical, and other fields. Rings with square, round, and oval cross-sections are furnished in sizes from 3/32 to 15/16 in. OD. Wall thicknesses are kept to 0.062 in. on a production basis, and to 0.012 in. on small-lot developmental seals. Seals provide improved mechanical, chemical, and thermal performance. **Tri-Point Plastics Inc.,** 175 I. U. Willets Rd., Albertson, L. I., N. Y. D



Circle 665 on Page 19

Miniature Insulated Wire

is rated for 300 v rms

Mini-Thin extruded Teflon-insulated wire has insulation wall thickness of 0.004 to 0.007 in. and is rated for 300 v rms. Wire is available for temperatures from − 90 to 250 C, and has stranded or solid conductor in sizes 36 through 22 AWG. It is color-

announcing . . .

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REFRASIL REINFORCED PLASTIC

for high temperatures to 5000° F. AND HIGHER!

ASTROLITE . . . a remarkable new high temperature material for Rocket and Missile insulation applications!

Out of HITCO's high temperature laboratories comes ASTROLITE . . . a **Refrasil-reinforced plastic** with impressive resistance to extremely high temperatures.

The excellent thermal shock characteristics and other outstanding physical properties of ASTROLITE make it an ideal insulation material to aid in Man's successful exploration of Space.

ASTROLITE is already proposed for use as liners for rocket engines and nozzles, nose cones for Intercontinental Ballistic Missiles and heat shields to protect critical components.

Complete technical data and dramatic proof of ASTROLITE's remarkable resistance to extremely high temperatures to 5000°F. **and higher** . . . is yours for the asking. Write to Director of Research.

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H. I. THOMPSON FIBER GLASS CO.
1733 Cordova St., Los Angeles 7, Calif.
Phone REpublic 3-9161

FREE NEW CHART!
Covers important points
to consider in selecting
high temperature insulation

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WRITE O[illegible] YOUR NEAREST HITCO REPRESENTATIVE: EASTERN: Tom Kimberly, 38 Crescent Circle, Cheshire, Conn., BRowning 2-6544 • **MIDWEST:** Burnie L. Weddle, 3219 West [illegible]eet, Indianapolis 22, Ind., WA 5-8685. • **SOUTHWEST:** Marshall Morris, 3515 Covert Avenue, Fort Worth, Texas, WA. 3-8098 • **NORTHWEST:** J. L. Larsen, 5757 Oakla[illegible] Seattle, Wash., MOhawk 9311 • **CANADIAN PLANT:** THE H. I. THOMPSON CO. OF CANADA LTD., 60 Johnston Street, Guelph Ontario, Telephone: TAylor 2-6630

Circle 505 on Page 19

***NEW* Complete Line of Hydraulic**

POWER STEERING

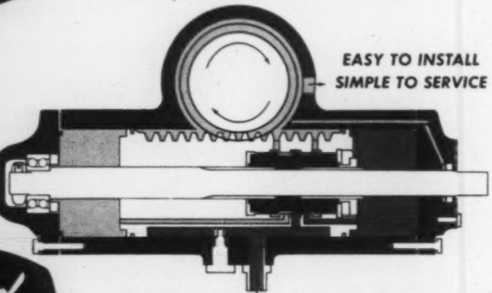
FOR EVERY PIECE OF STEERABLE EQUIPMENT BUILT

Compact, unified design permits installation of Sheppard Power Steering in most equipment without extensive engineering changes. Sheppard has 8 standard models . . . plus many special units . . . making it easy for you to offer full-time power steering on your equipment with the least delay and at lowest cost.

HIGH QUALITY AT LOW COST

Result of Simple, Rugged Design

Cutaway illustrates oil flow pattern, simplicity of design and minimum of moving parts in Sheppard Integral Power Steering Units.



Sheppard
POWER
Steering

FREE power steering folder yours on request . . . Write today! Sheppard's Engineering Staff is at your service to help you select the Power Steering best suited to your equipment.

R. H. SHEPPARD COMPANY, INC. • HANOVER, PA.

BUILDERS OF DIESEL ENGINES
AND POWER STEERING UNITS FOR INDUSTRY

Circle 506 on Page 19

THERE'S A WORLD OF DIFFERENCE *in Bearings*

Promet Engineered Bronze Bearings, Bushings and Wearing Parts absolutely will not powder in severest service, nor cut or stick to the shaft because of temporary lubrication failure. They give longer, trouble-free service or your money back.

Write for free literature and service data sheets or send prints and conditions of operation for recommendations and quotations. No obligation.

THE American Crucible PRODUCTS CO.

1321 Oberlin Avenue
Lorain, Ohio, U. S. A.

Circle 507 on Page 19

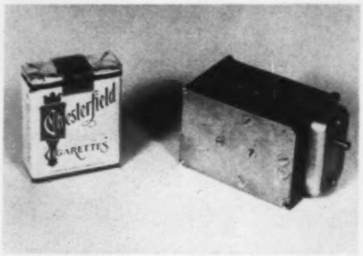
coded for circuit identification. Wire is supplied in continuous lengths on reels, or cut and stripped to specifications. Product has applications in airborne electronic equipment. **Thermax Wire Corp.,** 304 E. 45th St., New York 17, N. Y. D

Circle 666 on Page 19

DC Servomechanisms

provide high speed and torque in small size package

New dc servomechanisms are adaptable for control of aircraft surfaces, machine-tool drives, chemical and nuclear process control, test equipment, or any application where rotary or linear motion is required. Units feature high speed and high torque characteristics in a very small size package. Three models are presently available, providing 2 to 25 lb-ft torque. All three are equipped with transistors except for input stage, where vacuum tube permits use of units as replacements for or additions to high-impedance systems. Power takeoff is provided through spur-gear assembly. Servo feedback is provided by high-resolution, wire-wound potentiometer. Maximum shaft rotation at present is 56 deg. Model 2 (shown) weighs 12 oz; largest unit weighs 5 lb. **Advanced Research Associates Inc.,** 4128-B Howard Ave., Kensington, Md. C



Circle 667 on Page 19

Fan Motor

has simplified design

Type JN totally enclosed motor, for use on ventilating fans, is designed to be cooled by the airstream of the fan it drives. Because fan and guard are eliminated, motor is smaller and costs less

PRODUCT-DESIGN MEMOS FROM DUREZ

Insulative molding compounds | **Corrosion-resistant polyester**
Low-cost control knobs

Official U. S. Navy photo

But what if it rains?

From time immemorial, weather has upset the military plans of men. In colonial days, wet gunpowder could lose a skirmish. Today, one moisture-affected part can nullify months of costly labor on a new missile.

This helps to explain the increasing pressure on moisture-resistant insulations for electronic parts that must not fail. It explains, too, the growing interest in a relatively new Durez molding material, *diallyl phthalate*.

This is the *only* plastic that retains its high insulation values over extended periods at relative humidities above 90%.

Its arc resistance, as measured by ASTM D495 (Method A or B), can be consistently reproduced.

It does not corrode metal contact points.

Because it is a thermosetting material, it provides virtual freedom from cold flow and creep.

You can get this material from us as an orlon-filled granular blue or green molding compound with plasticity values of 10, 12, or 16 by ASTM D731. It is designed to meet the requirements of Mil-M-18794, Type SDI-5.

For a data sheet detailing properties of the compound, and of molded material, check the coupon.

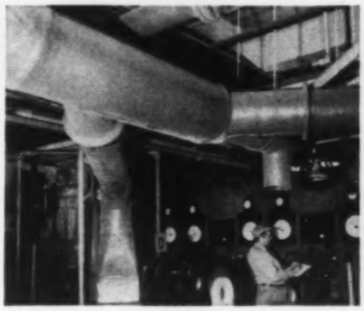
Hetron® ducts outlast metal

Perhaps you've been thinking of Hetron mainly as a *fire-retardant* polyester material.

It's true you get outstanding fire retardance with Hetron. But don't overlook its *corrosion resistance,* which is equally impressive in equipment such as this glass-reinforced ductwork manufactured by duVerre, Inc.

Venting corrosive fumes from a chemical reactor, aluminum ducts failed in 11 months. Ducts made of Hetron 92 replaced them—and have gone 17 months without a sign of deterioration.

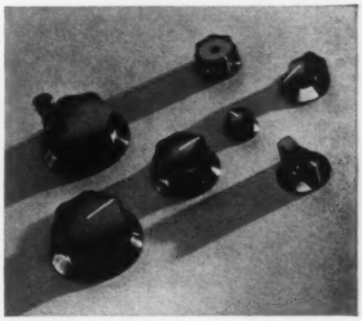
In another plant, Hetron 92 replaces rubber-lined steel ductwork which lasted less than a year under the corrosive bite of wet chlorine. The Hetron ductwork, in service four years, has required no maintenance and is as sound as the day it was installed.



duVerre, Inc.

Because it is self-extinguishing, you can safely specify Hetron in many places where a conventional polyester won't do. Fire retardance is *inherent*—does not depend on additives that might dilute corrosion resistance.

Are you taking full advantage of Hetron's unique qualities? A check mark on the coupon will bring you an illustrated bulletin outlining properties and uses of the versatile Hetron resin family.



Ready-tooled knobs

Why tool up for a standard item like a control knob, when you can buy general-purpose knobs like these—probably at a good saving?

Many custom molders can supply knobs in Durez phenolic, from stock tooling, to fit most standard mountings. You can have them hot-stamped with numbers or characters; equipped with special motifs.

Styled as a family, they blend smoothly with modern equipment lines; wipe clean without dulling; and stand up to heat, dampness, and corrosive atmospheres. For further information, consult your molder.

For more information on Durez materials mentioned above, check here:

☐ Diallyl phthalate, Durez 16694

☐ Hetron polyester resins (bulletin)

Clip and mail to us with your name, title, company address. *(When requesting samples, please use business letterhead.)*

DUREZ® HOOKER CHEMICALS PLASTICS

PLASTICS DIVISION
HOOKER ELECTROCHEMICAL COMPANY
502 Walck Road, North Tonawanda, N. Y.

Circle 508 on Page 19

MIDLAND

WELDING NUTS

take seconds to apply...
save hours of labor!

If you make a component part of an ultimate metal assembling operation requiring bolting in hard-to-get-at places, Midland Welding Nuts may well be the answer to simple, secure fastening later on. The practical Midland method anchors the nut in the exact location, ready to receive the bolt. There's no guesswork and cross-threading becomes impossible.

It's easy to apply Midland Welding Nuts.

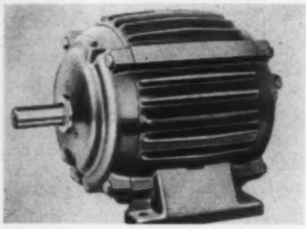
Just insert the collar in the hole for bolt or screw, resistance-weld the nut in place, and the nut is anchored for the life of the job. Nuts can be automatically fed to the welder to save time.

Midland Welding Nuts assure close fit of metal parts. They can't work loose, causing annoying rattles. Also, parts can be removed easily and quickly for replacement or repair without threat of losing nuts. Assembly workers prefer them because they turn stubborn, difficult jobs into simple, easy to handle projects, often converting two-man tasks into one-man operations.

MIDLAND-ROSS
CORPORATION
Executive Offices: Cleveland 1, Ohio

Formerly
THE MIDLAND STEEL PRODUCTS COMPANY
Cleveland • Detroit • Owosso, Michigan
And
J. O. ROSS ENGINEERING CORPORATION
New York City, N. Y.
Including John Waldron Corporation • Midwest Fulton Corporation • Ross Engineering of Canada, Limited
Andrews & Goodrich, Incorporated

Circle 509 on Page 19



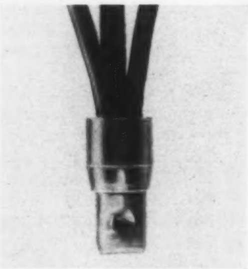
than prior designs. Incorporating transverse ball-bearing lubrication, asbestos-protected windings, cast-iron construction, and deep cooling ribs, motor is available in 1 to 15 horsepower range. **U. S. Electrical Motors Inc.,** Box 2058 Terminal Annex, Los Angeles 54, Calif. L

Circle 668 on Page 19

Splicing Connector

splices wide range of cable sizes

Burcap compression-installed, insulated fixture-type pigtail connector is rated 600 v for building wire and 1000 v for fixtures and signs. It splices a wide range of cable sizes, and is rapidly crimped to conductors with plier-type, ratchet, and pneumatic hand tools, or pneumatic bench-mounted tools. Link within each connector is tin-plated to resist corrosion and maintain low contact resistance. Insulation jacket is nylon. **Omaton Div., Burndy Corp.,** Norwalk, Conn. B



Circle 669 on Page 19

Miniature Connectors

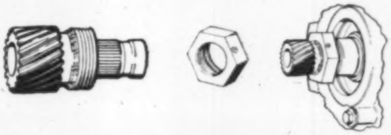
have taper-pin terminations

Miniature rectangular and hexagonal connectors are terminated for Amp 37 taper-pin receptacles. GHT hexagonal series provides sizes 4, 5, 7, and 9-contact arrangements, and GMT series offers 7 through 50-contact arrangements. Connectors are available in a variety of molded materials. They

From *Century* ... completely redesigned *Performance-Rated*© GEARMOTORS

Here they are ... new improved Century Gearmotors ... Performance-Rated for exact application of motor to job ... embodying that famous *Century dependability!* Available with Century polyphase, single phase and DC motors. Variety of mounting positions possible, including downshaft and tilted shaft.

Improved equipment performance for you with new improved *Century* Gearmotors



No pinion play, no creep even under reversing service! Motor shaft machined for high speed pinion assembly ... pinion splined into shaft and rigidly, positively locked in perfect alignment!

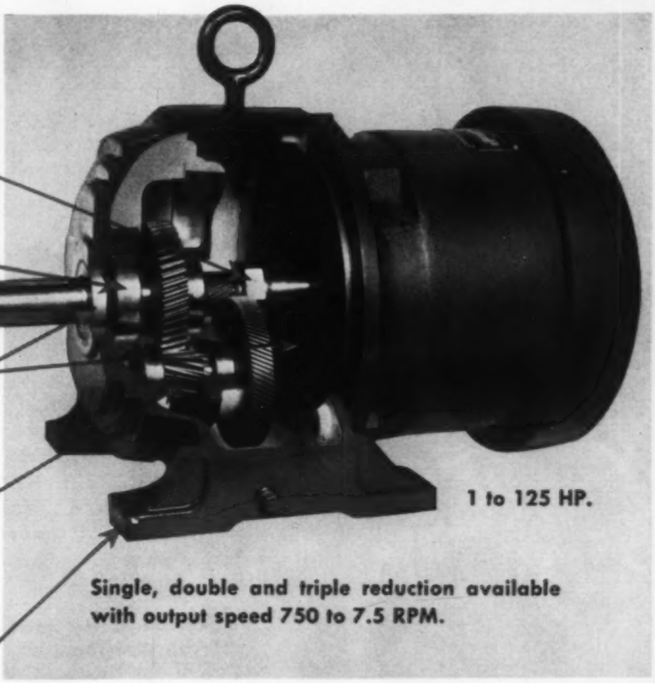
Trouble-free service even under heaviest loads and severest operating conditions is provided by extra-capacity bearings, integral bearing housings.

Cooler operation ... maximum wear life, and extra thermal capacity through improved case design and superior oil mist lubrication. Improved oil seals keep the lubricant *in* and foreign matter *out*.

More dependable power transmission ... higher capacity and longer wear life with Duti-Rated Lifetime helical gearing. Carefully controlled heat treating processes give file-hard tooth surfaces, tough ductile tooth cores.

Permanently accurate alignment of shafts, gears, bearings and seals assured by extra-rigid, cast gear housing. Alignment can't be distorted by overhung loads, uneven mounting surfaces, impact. Quick easy disassembly for inspection or maintenance without disconnecting from driven equipment.

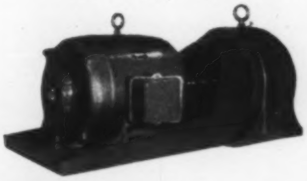
Century Gearmotors are Performance-Rated for precise application to your equipment requirements in the full Century range of motor size, speed, torque, mounting. Available in drip proof, explosion proof or totally enclosed frames.



1 to 125 HP.

Single, double and triple reduction available with output speed 750 to 7.5 RPM.

Century Gearmotor with shelf-type motor base.



Ideal for use on equipment for plants where motors must be interchangeable. Uses Century standard horizontal motor.

Investigate these improved Century Gearmotors now. For further details, call or write your nearby Century District Sales Office or Authorized Distributor.

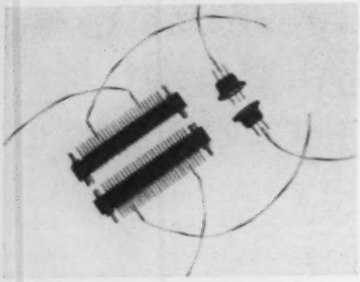
Performance-Rated©
MOTORS
1/20 to 400 HP

CENTURY ELECTRIC COMPANY

63

1806 Pine Street • St. Louis 3, Missouri • ***Offices and Stock Points in Principal Cities***

Circle 510 on Page 19



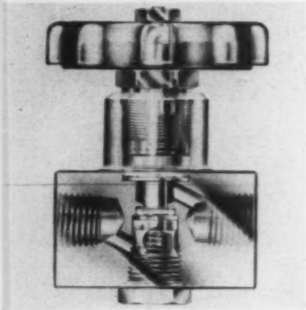
are equipped with polarizing guides and hood-cable enclosures with vibration clamps. Units exceed requirements of MIL-C-8384. **Electronics Div., Gorn Electric Co. Inc.,** 845 Main St., Stamford, Conn. B

Circle 670 on Page 19

Manual Shut-Off Valve

for missile and rocket applications

Model 949T manual shut-off valve provides positive, leakproof shut-off by means of a resilient O-ring which is withdrawn completely and automatically from fluid stream when valve opens. Throttling is then accomplished by a conical metal plug which varies orifice area. Both actions are accomplished in a single motion. Rated to 5000 psi, valve can be used in either hydraulic or pneumatic service. Applications include high-pressure gas systems, missiles, and rockets. **Circle Seal Products Co.,** 2181 E. Foothill Blvd., Pasadena, Calif. L

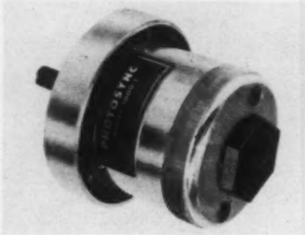


Circle 671 on Page 19

Rotary Switch

photoelectric unit is for high-speed operation

Photosync is a rotary-cam switch that employs a photo transistor and rotary shutter to obtain high resolution, high operating speeds, and long life. Direct coupled voltage change is produced whenever input shaft angle crosses one or more sets of two predetermined angular settings. Optical shutter mounted directly on input shaft gates light path between a 10,000-hr incandescent lamp and variable resistance photo transistor. Mechanical phase alignment is obtained by rotating dusttight cover assembly after completion of installation. Driving equipment can be run normally at full speed when making adjustment. Assembly includes sealed ball bearings for $\frac{1}{2}$-in. diam input shaft. Optical shutters can be cut for any angular limits between 0.1 and 358 deg. Mechanical phasing adjustment exceeds 360 deg. Electrical response time is essentially independent of rotational speed for shaft inputs under 5000 rpm. **Automation Inc.,** 212 Worcester St., Wellesley Hills 82, Mass. B

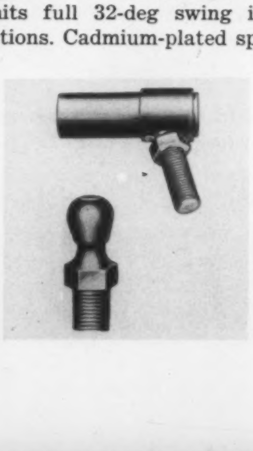


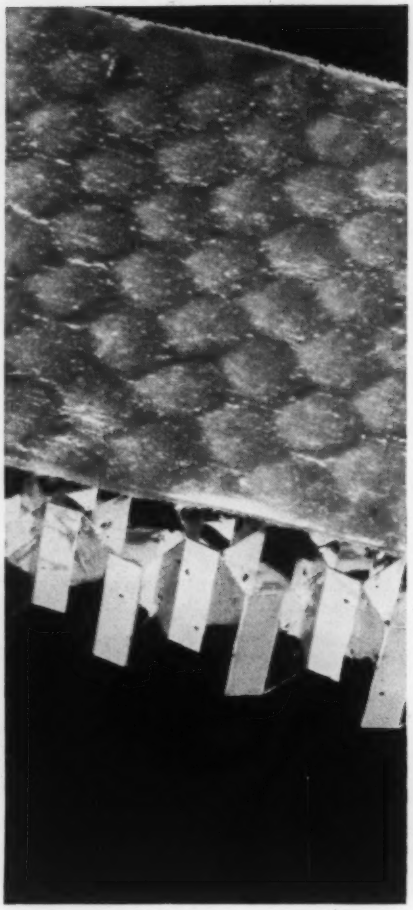
Circle 672 on Page 19

Ball Joint

permits 32-deg swing in all directions

Type SP heavy-duty ball joint is designed to eliminate binding and angularity problems. It is interchangeable with other SAE designs, but has larger neck section and greater tensile strength. Joint permits full 32-deg swing in all directions. Cadmium-plated spring-

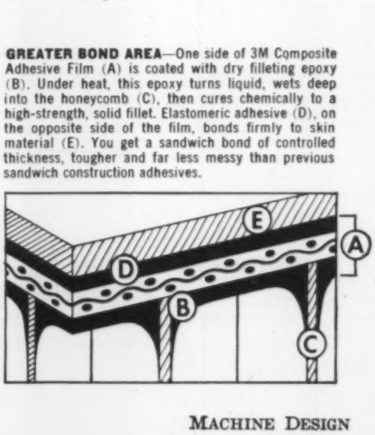


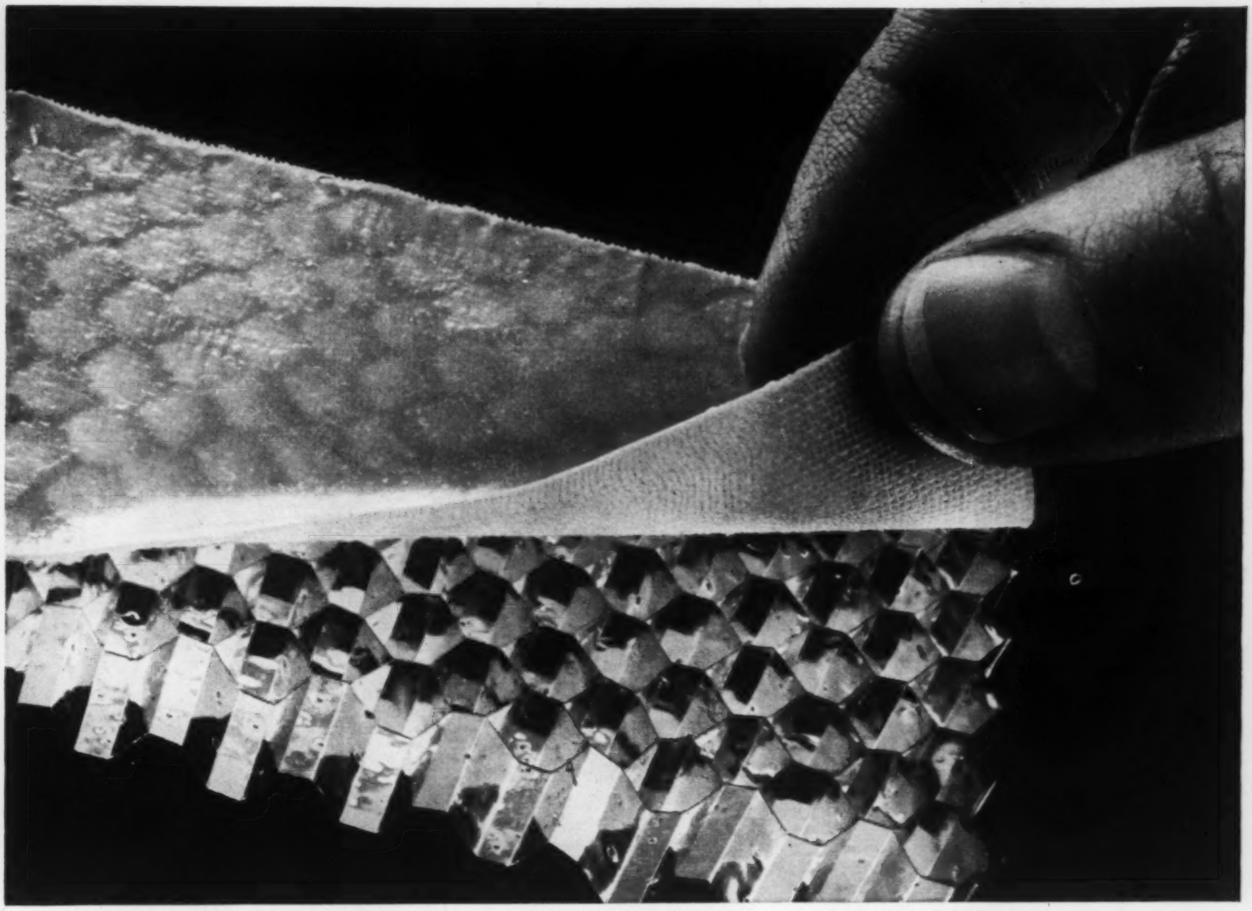


Dry/liquid

3M Research merges two technologies, creates new composite film adhesive

GREATER BOND AREA—One side of 3M Composite Adhesive Film (A) is coated with dry filleting epoxy (B). Under heat, this epoxy turns liquid, wets deep into the honeycomb (C), then cures chemically to a high-strength, solid fillet. Elastomeric adhesive (D), on the opposite side of the film, bonds firmly to skin material (E). You get a sandwich bond of controlled thickness, tougher and far less messy than previous sandwich construction adhesives.





THIS DRY ADHESIVE FILM will turn liquid when bonding heat is applied. A combination of epoxy resins and elastomeric components, it makes possible stronger honeycomb sandwich bonds for aircraft and many other industries, too.

adhesive helps jets fly faster

Today's jets fly faster, carry bigger payloads, thanks to a new 3M, dry/liquid adhesive film.

Thanks also to a daring leap of research imagination—from breweries to raincoats. Here's what happened:

The aircraft industry needed to bond honeycomb sandwich structures more strongly, more easily. 3M Research combined knowledge from two far distance sources. One, knowledge of deep filleting adhesives springing originally from glass-to-glass bonding in breweries. The other, knowledge of high peel strength adhesives stemming back to the apparel industry.

The result—a totally new adhesive family, 3M Composite Adhesive Films that turn liquid under bonding heat, avoid the messiness and handling difficulties of previous adhesives. They combine *both* deep filleting and high peel strength, make possible far stronger, lighter, more fatigue-resistant aircraft wings, speed production, cut fabricating costs.

Incredible to consider jets, breweries, raincoats all at once? Not for 3M. This ability to combine research in many fields is the superiority of a fully diversified adhesive manufacturer like 3M. And of its products, too. Only 3M has such broad adhesive experience.

WEATHERBAN

SEE WHAT 3M ADHESIVES CAN DO FOR YOU!

Call your 3M Field Engineer. Or for free literature write on your company letterhead to: 3M, Dept. C-2, 417 Piquette, Detroit 2, Michigan, stating your area of interest and adhesive need.

ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

Circle 511 on Page 19

CHROMALOX

electric cartridge heaters

POSITIVE LEAD WIRE PROTECTION FOR STANDARD AND HI-WATTAGE MODELS

New special features help Chromalox electric Cartridge Heaters provide longer life and more dependable spot heat. Use where abrasion or steam, oils or moisture limit heater life.

New high strength spring guard protects against stress and vibration. Moisture-resistant flexible brass conduit provides rugged, vapor-tight, drip-proof cover for lead wires.

Get the full story today. Write for Cartridge Heater Bulletin 850.

Edwin L. Wiegand Company
7575 Thomas Boulevard • Pittsburgh 8, Pa.

CHROMALOX FIRST NAME IN ELECTRIC HEAT

Circle 512 on Page 19

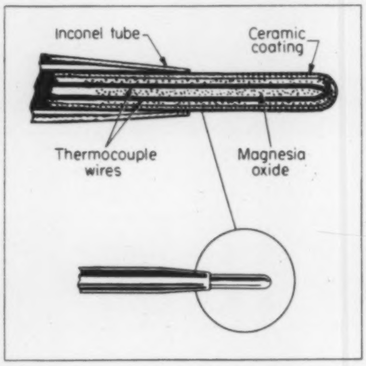
steel retaining sleeve gives ball cavity greater protection against abrasive particles. Buna-N rubber grommet is available for absolute protection against abrasive particles. Grommet rides freely on steel retaining sleeve without restricting motion of ball stud. Unit makes possible a multiple ball-joint rod-control assembly, with ball-joints installed at any point along length of rod. **Superior Ball Joint Corp.,** 8908 Trier Rd., Ft. Wayne, Ind. J

Circle 673 on Page 19

Universal Thermocouples

permit temperature measurements from −320 to 1900 F

Green Tip thermocouples are compatible with most liquids, gases, and nuclear radiation. They have fast response, are pressure-tight, and resist corrosion. High electrical insulation between inner sheath and Inconel tube is provided by a ceramic coating between sheath and overtube. Coating provides operating temperature range of −320 to 1900 F and pressure range of high vacuum to 2000 psi. Magnesium-oxide insulated thermocouple is welded integrally with sheath. **Aero Research Instrument Co. Inc.,** 315 N. Aberdeen St., Chicago 7, Ill. I



Circle 674 on Page 19

Permanent-Magnet Motor

miniature unit is for 6, 12, 27.5, and 115 v dc

Series B permanent-magnet motor has a diameter slightly over 1 in. No-load speeds are available from 3000 to 20,000 rpm. Standard gear units reduce final speed to

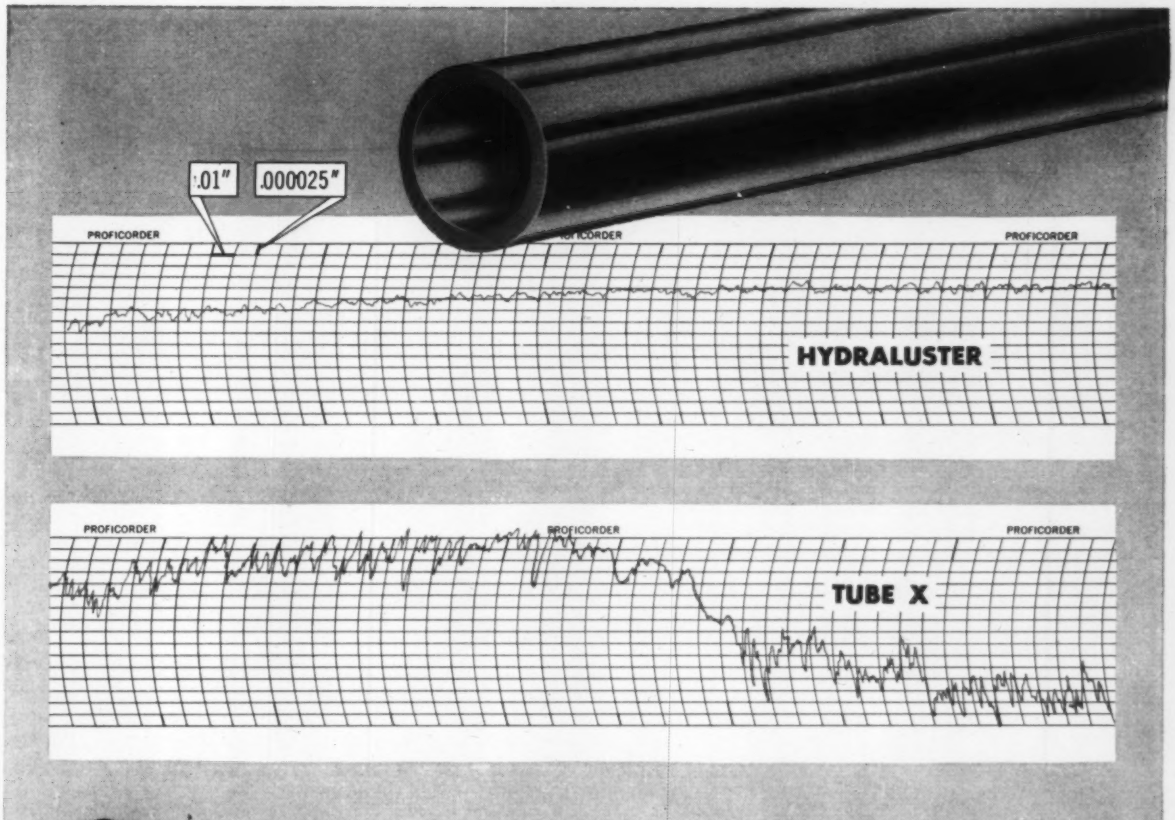
Servospeed HEART OF AUTOMATION

MODERN ELECTRONIC ENGINEERING GIVES PRECISE MOTOR SPEED CONTROL
1/100 — 10 H. P.

Modern industrial electronic engineering has been coordinated with electric motor design to provide a versatile means for obtaining the full possible advantage of speed control in DC motors while operated from the regular alternating current power line. Grid controlled "Thyratron" tubes are utilized for power controlled stepless variation to supply motor armature power. Patented feedback, or "Servo" circuits provide constant torque capability over wide speed ranges of as high as 60 to 1 in some models and a minimum of 20 to 1 in others.

Servospeed
DIV. of ELECTRO DEVICES, Inc.
4 Godwin Ave., Paterson, N. J.
ARmory 4-8989

Circle 513 on Page 19



VERIFICATION: Measurements of Hydraluster and Tube X were made on The Proficorder—an instrument of our manufacture for accurately showing the true profile of practically any machined or finished surface. The tests were conducted in our laboratories under my personal supervision. And I verify that both tubes were measured under identical conditions. The resulting graphs show the exact differences in the samples furnished. **Douglas Palmer — Chief Inspector, Micrometrical Mfg. Co., Ann Arbor, Mich.**

In micro-inch comparison of hydraulic tubing . . .

HYDRALUSTER shows smoothest, most friction-free I.D.

These graphic red lines are recorded measurements showing a surface profile *inside* both HYDRALUSTER and a length of standard hydraulic tubing. *Both tubes were selected at random from warehouse stocks*, then accurately measured in microinches by the sensitive stylus of the famous PROFICORDER.

Hydraulic system efficiency and dependability, in a large degree, depend on factors illustrated by the red lines. Tube X is *not* a scrap piece of tubing. In fact, it represents a quality grade purchased and used every day. Which tube would you select to offer the least resistance to hydraulic flow . . . to transmit fluid with the least amount of pressure drop . . . and to create the least fluid turbulence?

Hydraulic is the answer, of course. And Hydraluster is the right tube to specify when you want to insure these same performance characteristics in your hydraulic systems.

SAMPLES AND SPECIFICATIONS: Examine Hydraluster finish yourself. Your name on company letterhead will bring specifications and a sample by return mail. *Hydraluster is sold at standard carbon hydraulic tubing prices.*

Summerill

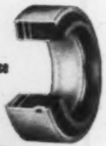
Tubing Company Division-Columbia Steel & Shafting Co.

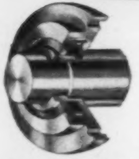
PITTSBURGH 30, PA. DEPT. NO. I-C1

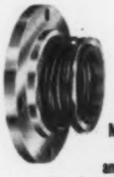
District Offices: Buffalo • Chattanooga • Cleveland • Dayton • Hartford • Philadelphia • Pittsburgh • Milwaukee • Chicago • Los Angeles • San Francisco

Circle 514 on Page 19

rotating shaft
seals
by Cartriseal
for all types
of products


Multi-Purpose Single Face "O" Ring.


Floating Labyrinth Seal for temperatures as high as 1400°F. and shaft speeds up to 150,000 rpm.


Metal Bellows Seals to fit any shaft size. Also: Cartridge Seals and Grommet Seals.

CUSTOM-ENGINEERED
to meet your specific requirements

Cartriseal solves seal problems of high rpm . . . temperature extremes . . . corrosion. Send specifications. No obligation.

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3515 W. TOUHY AVENUE LINCOLNWOOD 45, ILLINOIS
REPRESENTATIVES: NEW YORK • ROCHESTER • TOLEDO • CHICAGO • SOUTH BEND • LOS ANGELES • SAN FRANCISCO • SEATTLE

Circle 515 on Page 19

NEW **NEUTRAL POSITION SNAP ACTION HEAVY DUTY LIMIT SWITCHES**

Rugged, watertight LOXSWITCH Limit Switches are now available in snap action neutral position models. Each features two completely isolated circuits. Operating life extended up to five times. Low actuating force of 125 inch ounces. 70° safety overtravel.

DENISON
LOXSWITCH
SNAP ACTION
5″
2¼″

LOXSWITCH
MACHINE TOOL LIMIT SWITCHES

WATER-, DUST- & OIL-TIGHT • 3 TO 5 TIMES LONGER LIFE • SOUNDEST ELECTRICAL CIRCUIT • LOW COST

R. B. DENISON MFG. CO.
102 St. Clair Ave., N. W. • Cleveland 13, Ohio
SPECIALIZING EXCLUSIVELY IN LIMIT SWITCHES

Circle 516 on Page 19

D-C MOTOR
SERVO-TEK PRODUCTS
HAWTHORNE N.J.

as low as 1 rpm. Motors are available in 6, 12, 27.5, and 115 v dc. Balanced armature revolves on shielded ball bearings. Motor has an aluminum housing. **Servo-Tek Products Co.,** 1086 Goffle Rd., Hawthorne, N. J. D

Circle 675 on Page 19

Teflon Tube Socket

subminiature unit is compression-mounted

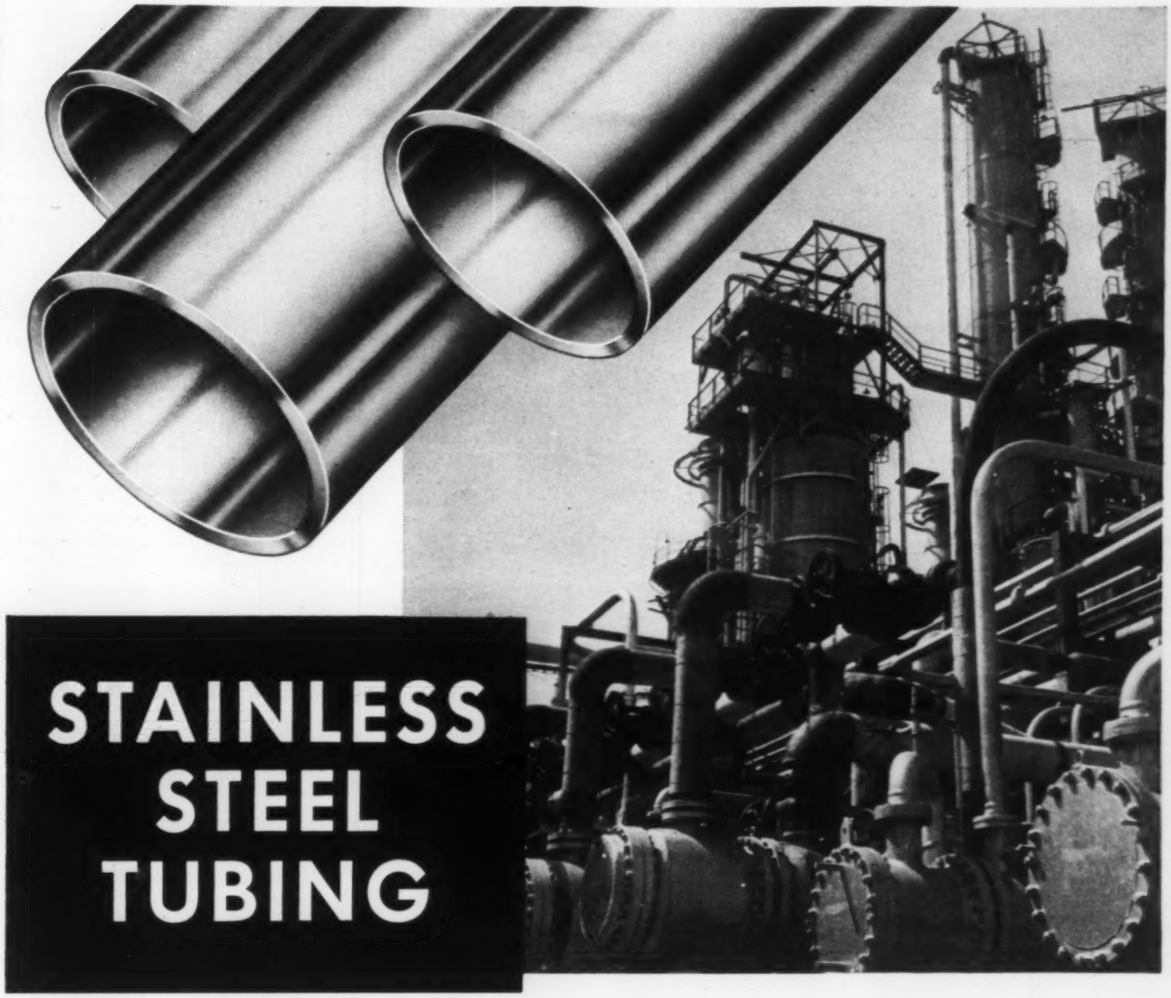
Chemelec Teflon subminiature tube socket has high reliability under conditions of extreme shock, vibration, and high temperature. Other properties include low-loss insulating qualities and zero moisture absorption. Compression-mounted design requires no mounting hardware, saves space and assembly time. Socket is pressed into a single chassis hole, slightly smaller than Teflon body of socket. Teflon expands to its original diameter to lock socket securely and permanently in place. Unit is used in printed circuitry and as chassis-mounted tube lead insulator. **Fluorocarbon Products Inc., Div., U. S. Gasket Co.,** Camden 1, N. J. E

Circle 676 on Page 19

Ball Bearings

for conditions involving extreme dirt and moisture

Power-transmission ball bearings accommodate commercially ground inch shafting and can be used in



STAINLESS
STEEL
TUBING

VITAL SPECIFICATION WHERE TEMPERATURES AND THRUPUT ARE BOOSTED

Stainless steel tubing is a wise choice in any heat exchanger or evaporator . . . on high temperature and high velocity operations stainless is a must. It offers strength, heat and corrosion resistance superior to any other material. Inert, stainless neither adds nor detracts anything from the solutions it transports. In operation, replacement is less frequent and losses from down-time for repairs are practically eliminated. When ordering new processing equipment, always specify stainless for low cost operation . . . for quality re-tubing requirements, be sure to specify Damascus.

Damascus offers a complete line of standard AISI analyses plus special alloy grades. Write now for complete information or call your LOCAL STEEL SERVICE CENTER.

FORMED STEEL TUBE INSTITUTE FSTI

AMERICAN STEEL WAREHOUSE ASS'N.

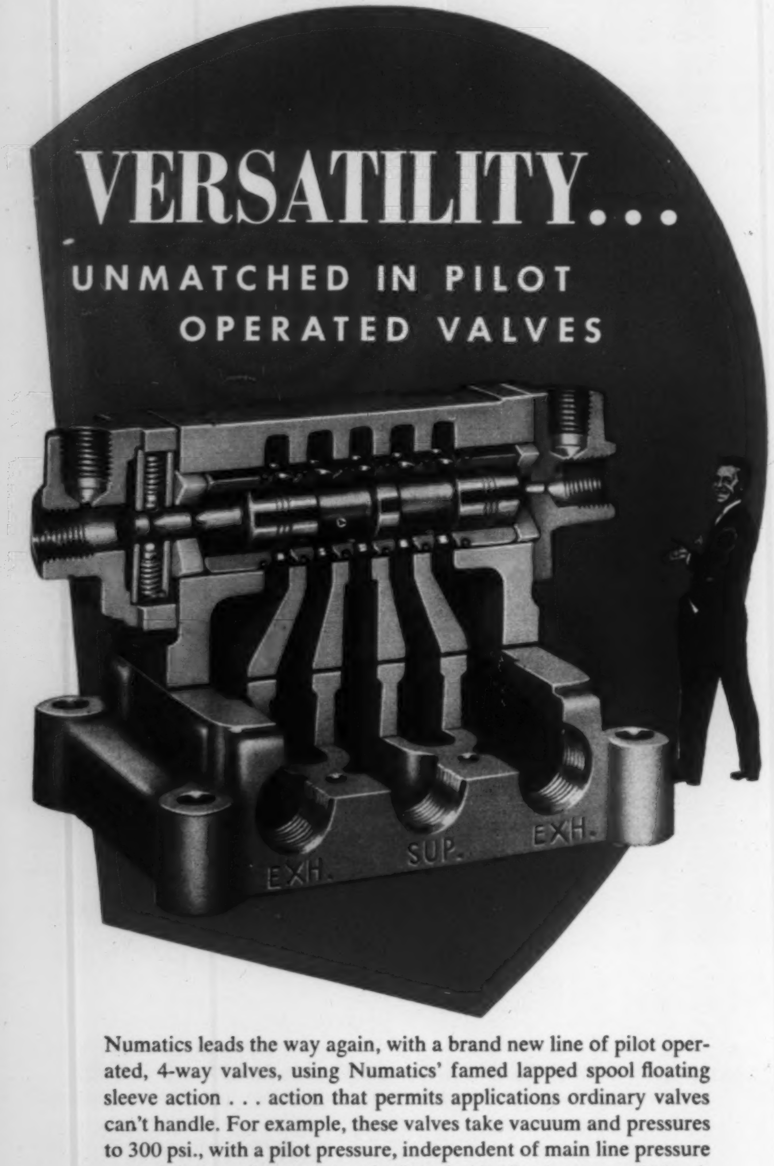
DAMASCUS TUBE COMPANY

STAINLESS STEEL TUBING AND PIPE

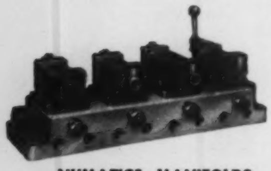
GREENVILLE, PENNSYLVANIA

Circle 517 on Page 19

Specify NUMATICS VALVES
. . . there are no "equivalents"


VERSATILITY...
UNMATCHED IN PILOT OPERATED VALVES
EXH.
SUP.
EXH.

Numatics leads the way again, with a brand new line of pilot operated, 4-way valves, using Numatics' famed lapped spool floating sleeve action . . . action that permits applications ordinary valves can't handle. For example, these valves take vacuum and pressures to 300 psi., with a pilot pressure, independent of main line pressure . . . minimum pilot pressure, in fact, is 10-15 psi. even at 300 psi. main line! Further, Numatics' new line offers nine different valving actions, four pipe sizes and mounting styles in *144 models* . . . every one a multi-purpose valve that can be used eight different ways! Want the whole story? Write today . . . or better, call your local Numatics engineer.



NUMATICS MANIFOLDS

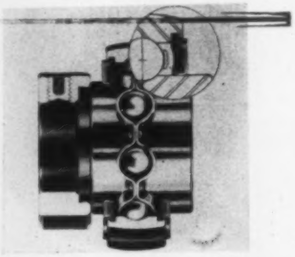
For mounting Numatics pilot operated or solenoid valves . . . interchangeably, if desired. Offered in 4 pipe sizes, 2 to 6 valve stations.

NUMATICS, Inc.
HIGHLAND, MICHIGAN Dept. MD

MINIATURE PILOT VALVES

Now, too, a complete new line of miniature pilot valves is available for application with Numatics pilot operated valves, Numatics manifolds.

Circle 518 on Page 19



standard pillow blocks. They are for use in conditions involving extremes of dirt and moisture. Metal flinger pressed on ground OD of inner ring forms a close-running labyrinth seal with outboard face of a synthetic-rubber element snapped into a groove in bore of outer ring. Flinger repels dirt and moisture, and protects thin, flexible lip of synthetic-rubber portion which runs on OD of inner ring, providing positive contact seal. **Marlin-Rockwell Corp.,** 402 Chandler St., Jamestown, N. J. F

Circle 677 on Page 19

Nitrile Rubber

resists ozone cracking

Hycar 1072 nitrile rubber has excellent oil resistance, good flexibility, high strength, and resistance to abrasion, oxidation, and ozone cracking. Applications include electrical insulation, especially near ozone-producing spark discharges, fabric coatings for indoor and outdoor uses, and in finished parts which are under tension for long periods. **B. F. Goodrich Chemical Co.,** 3135 Euclid Ave., Cleveland 15, Ohio. F

Circle 678 on Page 19

Indicator Lights

for heavy-duty industrial applications

Oil, water, and dust-tight indicator lights are for use in heavy-duty industrial applications. Built-in resistors permit use with NE-51 neon glow lamps on voltages to 250 v. Similar lights are made with-

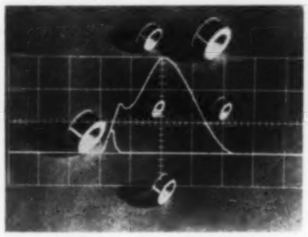
out the resistor for use with low-voltage incandescent lamps with miniature bayonet base. Stovepipe lens (shown) is fluted type and provides visibility in all directions. Lens can also be specified as plain, unfrosted, or with frosted back. Seven lens colors are available. Terminals are screw or soldering type. **Dialight Corp.**, 60 Stewart Ave., Brooklyn 37, N. Y. D

Circle 679 on Page 19

Magnetic Bobbin Cores

in tape widths from 1/32 to 1 in.

Magnetic bobbin cores are for digital data processing systems, small pulse transformers, and high-frequency magnetic amplifiers. Cores are available in either 4-79 molybdenum permalloy, rectangular hysteresis loop material containing 4 per cent molybdenum, 79 per cent nickel, and 17 per cent iron, or Orthonik, a rectangular hysteresis-loop material containing 50 per cent nickel and 50 per cent iron. Cores are protected by Mylar tape or nylon caps wherever additional protective covering is desirable. They are available in tape widths from 1/32 to 1 in. and tape thickness from 1/8 to 1 mil. Complete range of bobbin sizes is available. **G-L Electronics**, 2921 Admiral Wilson Blvd., Camden 5, N. J. E



Circle 680 on Page 19

Spring Pins

vibrationproof units are of beryllium copper

Sel-Lok spring-pin fasteners are now available in beryllium copper alloy. Material is nonsparking, nonmagnetic, and has high conductivity. Pins range in size from 0.062 to 0.250 in. in diam. Lengths range from 3/16 to 4 in., and length

NOW... ALL COLORS...
REPRODUCE PERFECTLY
J.S. STAEDTLER MARS-LUMOCHROM DRP. GERMANY
2628 J.S. STAEDTLER MARS-LUMOCHROM DRP. GERMANY

MARS-LUMO CHROM

makes possible an important new drafting technique. It's not just a colored pencil; it's a *color-drafting* pencil. Twenty-four colors—and every one reproduces perfectly. Lets you draft with as many colors as you need. Saves time, prevents mistakes.

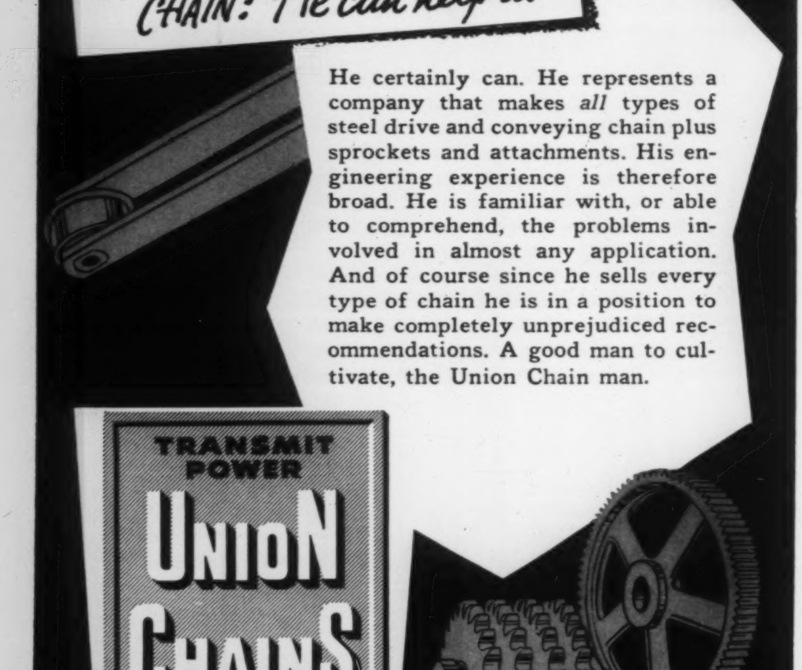
• won't fade • won't smear • really waterproof
• erases perfectly • keeps finest point

Send for free sample

Other new Mars products include: the Mars-Pocket-Technico for field use, the Mars "Draftsman's" Pencil Sharpener with the adjustable point-length feature, and the efficient, clean Mars lead sharpener. All available – along with the established standards: Mars-Lumograph black graphite drafting pencils, Mars-Technico lead holder and leads, and Tradition-Aquarell painting pencils – at all leading engineering and drafting supply dealers.

J.S. STAEDTLER, INC. HACKENSACK, NEW JERSEY

Circle 519 on Page 19



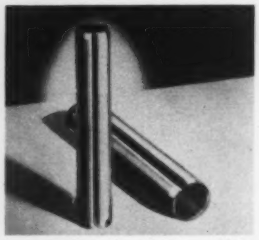
MEMO TO H.R.
FROM V.L.
Are we using the field engineer from UNION CHAIN? He can help us.

He certainly can. He represents a company that makes *all* types of steel drive and conveying chain plus sprockets and attachments. His engineering experience is therefore broad. He is familiar with, or able to comprehend, the problems involved in almost any application. And of course since he sells every type of chain he is in a position to make completely unprejudiced recommendations. A good man to cultivate, the Union Chain man.

The Union Chain And Manufacturing Company

SANDUSKY, OHIO

Circle 520 on Page 19



tolerances range from ± 0.015 in. in smallest sizes to 0.030 in. in largest sizes. Hardness of the vibrationproof pins is Rockwell C 36-42. Minimum shear strengths are approximately 60 per cent those of standard carbon-steel spring pins. **Standard Pressed Steel Co.,** Box 102, Jenkintown, Pa. C

Circle 681 on Page 19

Motors

use new oil wicking to reduce motor size

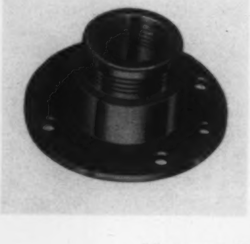
Fractional-horsepower motors using Perma-wick, a new oil wicking material, are available for fans and air conditioners. Wicking material holds more oil per unit volume of material than felt, permitting smaller lubricating space and shorter motors. Wicking also has better oil retention at normal operating temperatures. Material is inserted in motor end shields like grease. Ratings of motors range from 1/80 to 1/6 hp for shaded-pole types, and from 1/20 to 1/3 hp in permanent split-capacitor types. **Westinghouse Electric Corp.,** P. O. Box 2099, Pittsburgh 30, Pa. F

Circle 682 on Page 19

Rotary Face Seal

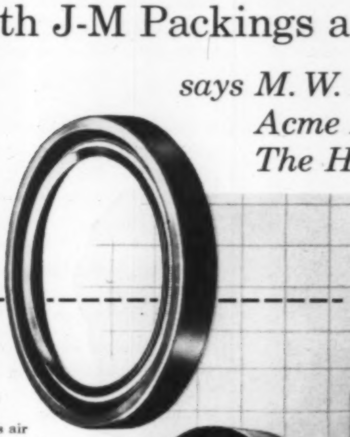
for high-speed rotating shafts

New rotary face seal operates in temperatures from −320 to 1200 F. It is for use in difficult seal-

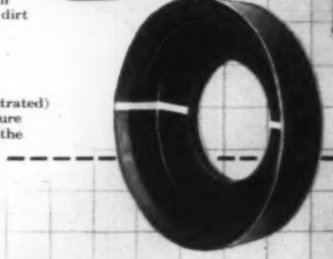


"Customer satisfaction hit a new high when we redesigned Acme forging machines with J-M Packings and Friction Materials,"

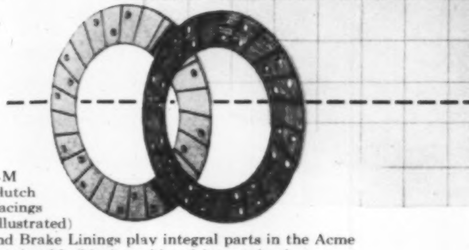
says M. W. Lamprecht, Chief Engineer
Acme Machinery Division
The Hill Acme Company



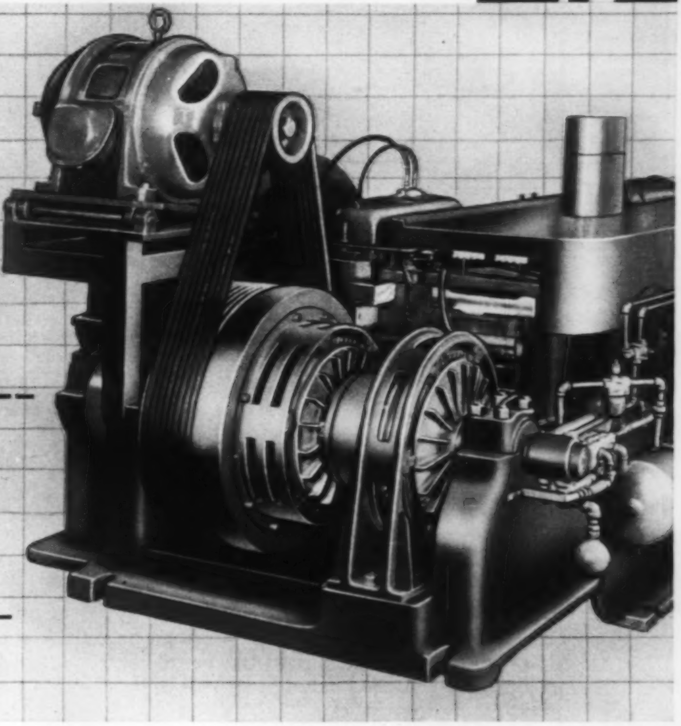
J-M Clipper Seals protect the Acme Forging Machine's air distributor from air, dirt and abrasives.



J-M "A" Cups (illustrated) and Hat Gaskets insure smooth operation of the air cylinder.



J-M Clutch Facings (illustrated) and Brake Linings play integral parts in the Acme Forging Machine's cushion drive mechanism.



Acme Forging Machines are widely used by metalworking plants all over the world. They are made by Hill Acme Co., pioneers and leaders in construction and design of modern forging machines.

J-M products defy extreme thermal and mechanical shock for dependable performance and long life

In terms of thermal and mechanical shock and the constant presence of dirt, chips and other abrasives, Acme Forging Machines provide one of the most rugged tests ever devised for packings and friction materials. In more than 20 years of service, Johns-Manville products have achieved an enviable record with Acme users. Performance has been more than satisfactory in every way and replacement has been held to the minimum.

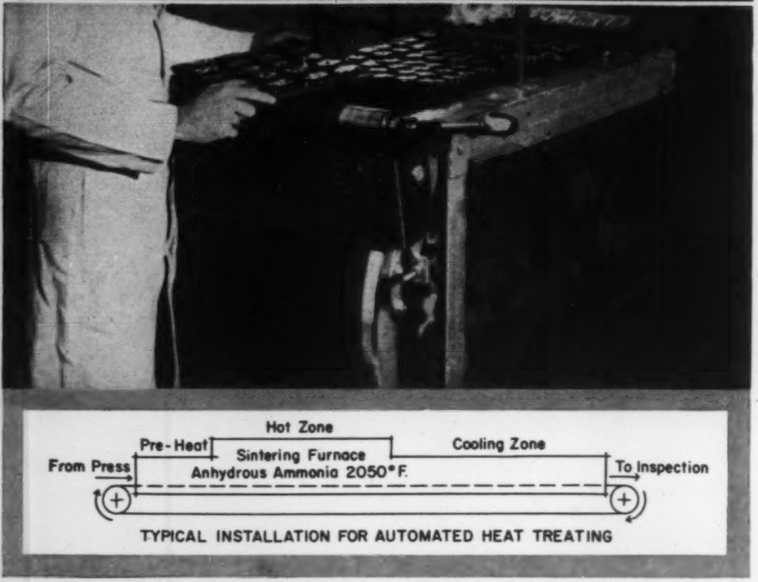
Johns-Manville makes a complete line of packings, gaskets, asbestos textiles, brake linings, clutch facings, transmission bands and industrial friction materials. Chances are one or more of these products may provide the answer to your design problems. For further information call your local J-M sales office or write Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

JOHNS-MANVILLE

JOHNS-MANVILLE JM PRODUCTS

Circle 521 on Page 19

Cambridge WOVEN WIRE BELTS


Hot Zone
Pre-Heat
Sintering Furnace
Anhydrous Ammonia 2050°F.
Cooling Zone
From Press
To Inspection
TYPICAL INSTALLATION FOR AUTOMATED HEAT TREATING

METAL-MESH BELTS CUT COSTS, INCREASE PRODUCTION IN CONTINUOUS PROCESSING

Continuous movement of metal parts, foods, chemical or ceramic products through practically any type of processing operation eliminates batch processing and manual handling for faster, more economical, more uniform production. Through wet, cold, hot or dry operations, Cambridge Belts give you all these advantages:

ALL-METAL CONSTRUCTION IS HEATPROOF, COLDPROOF, RUSTPROOF—Cambridge Belts can be woven from any metal or alloy, thus can be made impervious to damage from temperatures from sub-zero up to 2100° F., water, acids or caustic solutions.

OPEN MESH PROVIDES FREE CIRCULATION—process atmospheres pass freely through the belt for uniform processing of the parts in the load, process solutions drain through the mesh in a flash.

WOVEN WIRE CONSTRUCTION—has no seams, lacers or fasteners to wear or break—reduces maintenance costs and eliminates frequent belt replacements.

SPECIAL SURFACE ATTACHMENTS AVAILABLE—raised edges or cross flights to hold product on belt during movement.

Whether you design machinery for your own use or for resale, your Cambridge FIELD ENGINEER can explain how the many advantages of Cambridge belts make automated processing practical and economical. And, he'll recommend the belt size, mesh or weave—in the metal or alloy—best suited to your operation. Call now. He's listed in the classified phone book under the heading "BELTING, MECHANICAL". Or, write for FREE 130-PAGE REFERENCE MANUAL giving mesh specifications, design information and metallurgical data.

The Cambridge Wire Cloth Co.

WIRE CLOTH | METAL CONVEYOR BELTS | SPECIAL METAL FABRICATIONS

Department N,
Cambridge 2,
Maryland

OFFICES IN PRINCIPAL INDUSTRIAL CITIES

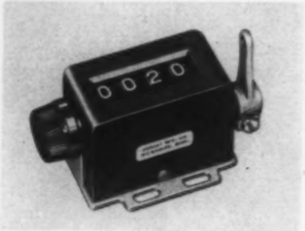
speed rotating shafts. Leakage is impossible, since bellows spring seal is a machined part without openings. Seal face, in combination with bellows spring, remains stationary against rotating shaft face. Facings are of carbon, tungsten-carbide, or other suitable material, according to temperature and pressure requirements. **Skinner Seal Co.,** 3001 Sutter St., Santa Ana, Calif. L

Circle 683 on Page 19

Small Stroke Counter

has speeds up to 1000 counts per min

Model 4-X-1-1 is a medium-duty counter with right or left-hand drive, and speeds up to 1000 counts per min. Shafting of stainless steel and drive parts of nylon provide long life and excellent wear. Counter is entirely sealed to prevent entrance of dust and moisture into working parts. Applications include use on equipment such as duplicators, card-sorting machines, business machines, laboratory equipment, vending machines, light presses, and similar equipment. **Durant Mfg. Co.,** 1933 N. Buffum St., Milwaukee 1, Wis. K



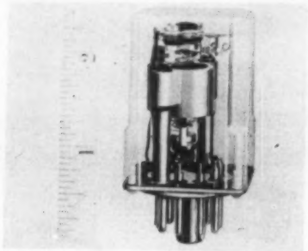
Circle 684 on Page 19

Meter-Relay

incorporates clear plastic case

Use of a clear plastic case on Model 137 meter-relay permits observation of operation of moving element. Unit has a moving-coil armature which rotates in the flux gap of an Alnico magnet. Movement rides on polished pivots in vee-cup jewels. Contact-locking coil develops high contact pressure, assuring good operation even under

Circle 522 on Page 19



vibration of 10 g from 5-200 cycles. Coil is rated 5-25 ma dc. Reset, which opens the locking circuit, can be manual or automatic. **San Gorcinto Div., Assembly Products Inc.**, P. O. Box XX, Palm Springs, Calif. F

Circle 685 on Page 19

Hydraulic Pumps

designed for heavy-duty power-steering systems

Vane-type hydraulic pumps, designated Series V200, incorporate an integral flow control and pressure-relief valve to provide good performance at all engine speeds. Pumps are adapted for power-steering systems of trucks with heavy front-axle loading. Nominal rated capacities are 5, 8, and 11 gpm at 1200 rpm, and maximum speed is 2200 rpm. All sizes are available with controlled flow rates of 2, 4, 6, and 7 gpm at relief valve setting of 750 or 1000 psi. Hydraulic balancing eliminates pressure-induced bearing loads and reduces maintenance. **Vickers Inc.**, Detroit 32, Mich. H

Circle 686 on Page 19

Subminiature Potentiometers

incorporate semihermetic seal

Mite-E-Mite precision potentiometers are available in bushing, servo, and solder-mountable models. Semihermetic seal consists of an O-ring seal and glass-sealed

MAKE SURE EVERY
component*
ADDS MORE
TO YOUR QUALITY PRODUCT

When you specify Ingersoll-Rand* you are certain to get modern design with efficient, economical performance. This is why you'll see reliable Ingersoll-Rand Motorpumps on equipment requiring the best centrifugal pump.

Let us tell you about our most complete line of Motorpumps with built-in dependability and versatility. Write for our latest literature.

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by
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11 Broadway, New York 4, N.Y.

Sidewall, immersion or foot mounted there's an Ingersoll-Rand Motorpump to suit your requirements.

9-592

Circle 523 on Page 19

U.S. AIR FORCE
The might of VOODOO was proved with Statham Transducers

IN THE F-101

Statham transducers gathered pressure and acceleration data in McDonnell Aircraft Corporation's program to prove out the aerodynamic design and structural design.

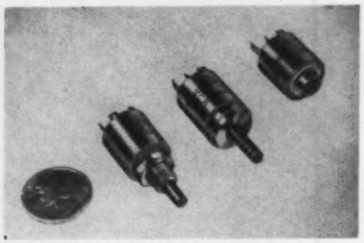
WHEN THE NEED IS TO KNOW...FOR SURE SPECIFY STATHAM

Accelerometers • Load Cells
Pressure Transducers

Catalog, complete with prices, available upon request.

Statham
INSTRUMENTS, INC.
LOS ANGELES 64

Circle 524 on Page 19



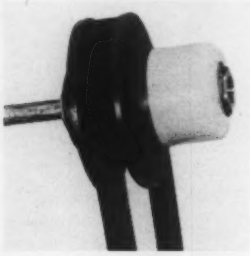
header. Resistance is up to 150 K ohms, and ambient temperature range is −55 to 125 C. **General Scientific Corp.,** 1509 First St., San Fernando, Calif. L

Circle 687 on Page 19

Variable-Pitch Pulley

is of nylon-impregnated glass fiber

Model VP-2 self-lubricating 3¼-in. variable-pitch pulley for fractional-horsepower motors has 2.45:1 speed range, spring-loaded tension, and ½ and ⅝-in. shaft bores. Manufactured from nylon-impregnated glass fiber, unit has excellent corrosion resistance. Typical applications include appliances, light machinery, business machines, and any adjustable-speed equipment to ⅓ hp. **Rampe Mfg. Co.,** 14915 Woodworth Ave., Cleveland 10, Ohio. G



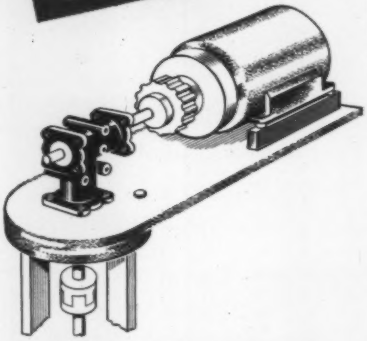
Circle 688 on Page 19

Silicone-Rubber Compounds

for temperatures to 500 F

Uses for two new room-temperature vulcanizing silicone-rubber compounds include encapsulation of electric and electronic components, sealing and filling voids, protecting parts against vibration and moisture, repairing or replacing rubber gaskets and seals, caulking and glazing, and model making. A red compound, designated 81712, has extremely low

ANGLgear® simplifies power package design



Drawing based on photo shows ANGLgear power takeoff on power package for liquid tar pump. ANGLgear's compactness and 4-way mounting simplified design of unit, helped reduce size.

In designing a power package for a portable tar pump used in roofing work, Continental Cleveland Corp., Cleveland, Ohio, needed a simple, compact 90° power takeoff to stand rough service and handle heavy transmission loads.

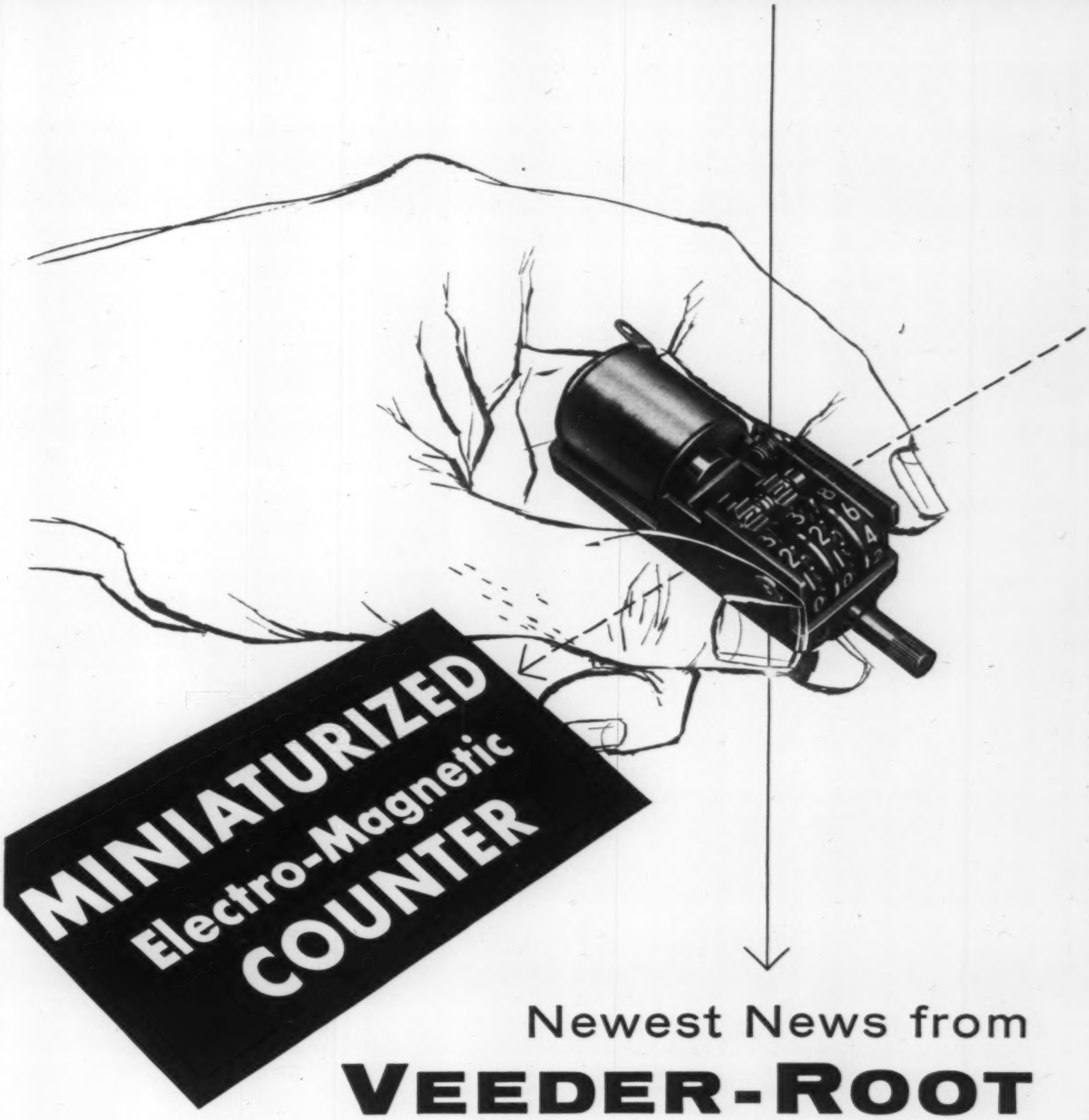
A Model R-340, 5 hp ANGLgear met these requirements perfectly. Because of its compactness and 4-way mounting feature, it was easily designed into the power train and helped reduce the size of the entire power unit. It also had the necessary stamina to absorb the loads involved in pumping liquid tar to heights up to 90 ft. Completely enclosed, it could not be fouled by the tar.

Perhaps ANGLgear can solve a 90° drive problem for you. Designed for manual or power operation, ANGLgears are available from stock in 1/3 to 5 hp ratings, with 2 or 3-way shafting, and 1:1 or 2:1 gearing.

See our literature in Sweet's Product Design File or contact your local distributor.

AIRBORNE®
AIRBORNE ACCESSORIES CORPORATION
HILLSIDE 5, NEW JERSEY

Circle 525 on Page 19



Newest News from
VEEDER-ROOT

Series 1527 Veeder-Root Miniaturized Electro-Magnetic Counters were originally developed for use in aerial cameras. These and similar counters are used to "post" the number of film-exposures, gallons or rounds of ammunition remaining after each use.

The new miniaturized counters present a frontal area less than 1″ x 1″ . . . save an important amount of space over the older, larger counters. Yet they are designed to operate at speeds as high as 900 counts per minute. And this modern design includes a new push-in bi-directional reset knob, with speed-up gearing. Specifications meet most military requirements. Write for full details.

Added Evidence
that *__Everyone__*
Can Count on

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Circle 526 on Page 19

WHAT'S YOUR CLAMPING PROBLEM?

WITTEK

HAS THE ANSWER

Here is a selection from among the many different types and sizes of hose clamps designed and manufactured by WITTEK. Whatever the hose connecting problem, it's a safe bet that WITTEK (leader for over a quarter century) has the *exact* type and size clamp to do the job right! Let WITTEK help solve *your* clamping problems. Write today.

5187

WITTEK MANUFACTURING COMPANY

4349 West 24th Place • Chicago 23, Illinois

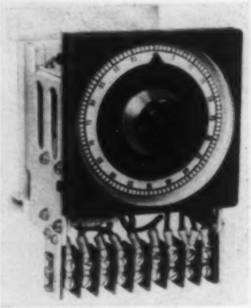
Circle 527 on Page 19

shrinkage. It is available for model making, sealing, and other uses where accuracy and dimensional stability are important. Compound 81726, a beige material, is harder and tougher but not as elastic, shrinking about 2 per cent during cure. Both compounds possess excellent ozone and weathering resistance, flame resistance, low temperature flexibility, good electrical properties, and good performance at temperatures to 500 F. **Silicone Products Dept., General Electric Co.,** Waterford, N. Y. C

Circle 689 on Page 19

Add-Subtract Counter

for conveyor and inventory systems



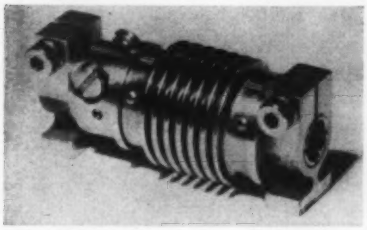
Add-subtract counter automatically controls the number of units in a given area, making it suitable for application with conveyor systems, inventory systems, and automatic storage hoppers. Add and/or subtract pulses can be fed to the unit in any sequence, or simultaneously, without miscount. Single-pole, double-throw switches are actuated when minimum or maximum count is reached. Counter, wired for continuous count, also receives add or subtract pulses continuously, 100 pulses per revolution. Cams are available for 5, 10, 20, and 25 counts per output pulse. Unit has 10-amp contacts and is available in 115 or 230-v, 60-cycle models. **Eagle Signal Corp.,** 202 20th St., Moline, Ill. I

Circle 690 on Page 19

Coupling

for pin and clamp-type hubs

Zero adjustable stainless-steel bellows coupling permits precision ad-



justment on sensitive shafts of servo motors, resolvers, and synchros. It is designed for 360-deg continual rotation and adjustment. Range of adaptability is for four basic shaft sizes—1/8 to 1/8, 3/16 to 3/16, 1/4 to 1/4, and 0.1200 to 1/8—and can be applied on pin and clamp-type hubs. **PIC Design Corp.**, 477 Atlantic Ave., East Rockaway, N. Y. D

Circle 691 on Page 19

Electric Motors

in range of sizes from 1/3 to 800 hp

Expanded line of motors ranges from 1/3 to 800 hp and includes new explosionproof, totally enclosed and splashproof models. Some of the types available are: Fractional-horsepower models rated from 1/3 to 1 hp capacitor-start or polyphase induction; single-phase integrals from 1 to 5 hp; polyphase dripproof integrals from 1 to 800 hp, jet-pump models from 1/3 to 3 hp, including sealed starting switch; hermetics from 3/4 to 100 hp for compressor use; explosionproof units from 1 to 500 hp; coupled pump motors from 1 to 75 hp, designed for centrifugal pumps. **Electric Motor Div., A. O. Smith Corp.**, 531 N. Fourth St., Tipp City, Ohio. G

Circle 692 on Page 19

Pressure Switches

operate in temperatures from − 65 to 275 F

Line of pressure switches is available in materials suitable for use

MELETRON
MODEL 1100

New PRECISION FREQUENCY

STATIC INVERTER SUPPLY

INPUT 28V D.C. ± 10%

OUTPUT Nom. 115V ± 2% 400 CPS ± 0.01%
1 ø (2- or 3-phase output available)

RATINGS: 30VA 50VA 100VA
Higher ratings available.

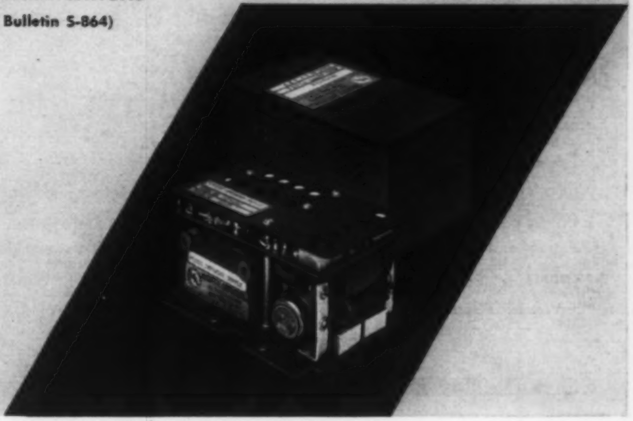
APPLICATION:

For gyro wheel supplies and where precise 400 cycle voltages are required in aircraft, radar and missile computers.

FEATURES:

PRECISION OUTPUT FREQUENCY
RUGGED
EXCELLENT WAVEFORM
SIMPLICITY OF CIRCUITRY
FAST STARTING TIME
GOOD VOLTAGE REGULATION
throughout an adjustable range
ISOLATED CASE DESIGN
HIGH RELIABILITY
VIBRATION ISOLATED
COMPACT
LIGHTWEIGHT
MILITARY SPECIFICATIONS

(Send for Bulletin S-864)



PERFORMANCE SPECIFICATIONS

MODEL NUMBERS	± .01% CPS	SIS 40311	SIS 40511	SIS 410011
	± .05% CPS	SIS 40315	SIS 40515	SIS 410015
INPUT VOLTAGE		28V DC ± 10%		
MAX. OUTPUT POWER		30VA	50VA	100VA
OUTPUT VOLTAGE		115V AC (Adjustable ± 10%)		
OUTPUT FREQUENCY		400 CPS ± .01% 400 CPS ± .05%		
VOLTAGE REGULATION		±1% For Line Variations ±2% For Load Variations		
FREQUENCY DISTORTION		3% Maximum At Full Load		
LOAD POWER FACTOR		+0.5 to − 0.5 Maximum		
MILITARY SPECS.		MIL-E-5400A & MIL-E-5272A		
AMBIENT TEMPERATURE		− 55°C to + 71°C when mounted to heat sink		
VIBRATION		20G 10 to 2000 CPS		
UNIT DIMENSIONS		L5" D 2 7/8" H 2 13/16"	L8" D 2 7/8" H 2 13/16"	L10" D 4 1/2" H 2 13/16"
WEIGHT (Approx.)		2 lbs.	3.5 lbs.	5 lbs.

MA
MAGNETIC AMPLIFIERS INC.
632 TINTON AVENUE • NEW YORK 55, N. Y. • CYPRESS 2-6610
West Coast Division
136 WASHINGTON ST. • EL SEGUNDO, CAL. • OREGON 8-2665

Circle 528 on Page 19

HILLIARD CLUTCHES FOR POWER CONTROL DESIGNS

HILLIARD *Single Revolution* CLUTCH

1 ACCURATE dependable action through millions of cycles.

3 POSITIVE motion without slip or lag.

2 INSTANT ENGAGEMENT at any point in the the revolution of the driver.

4 RENEWABLE CAM SURFACES without machining or new parts.

The Hilliard Single Revolution Clutch *is automation* because it provides precise accurate intermittent motion automatically. Control can be electrical or mechanical.

The use of Hilliard Single Revolution Clutches has improved the operation of tube straightening and cut-off machines—shears—conveyors—riveting and fastening units—case loaders—bottle unscramblers—weighing and packaging—indexing and feeding—marking—punching—textile and business machines—radar apparatus—proportionate pumps—and many other types of mechanisms.

WRITE TODAY FOR BULLETIN 239 WITH COMPLETE INFORMATION.

• OTHER HILLIARD CLUTCHES •

CONSIDER AUTOMATION - INVESTIGATE THESE PRODUCTS

HILLIARD - TWIFLEX CENTRIFUGAL COUPLING for smooth, easy starting of any load automatically with overload protection and ability to accommodate shaft misalignment.
Ask for Bulletin CE-3.

OVER - RUNNING CLUTCHES for automatic instantaneous engagement and release on two speed drives, dual drives and ratchet or backstop action.
Ask for Bulletin 231.

SLIP CLUTCHES for overload protection, or constant torque and to provide constant tension and permit speed variation on rewind stands.
Ask for Bulletin 300.

THE HILLIARD Corporation
MANUFACTURING CLUTCHES FOR OVER 50 YEARS
103 W. FOURTH ST. ELMIRA, NEW YORK

IN CANADA: UPTON • BRADEEN • JAMES, LTD.

Circle 529 on Page 19

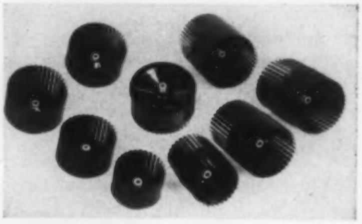
with acids and highly corrosive materials. Proof pressures range from 224 to 6000 psi, pressure settings from 2 to 4800 psi. Switches operate in temperatures from −65 to 275 F. Standard pressure-port fitting is 1/4 in. internal pipe thread. Single-pole, double-throw switching elements are rated to 10 amp, for ac and dc circuits. Stainless-steel models withstand temperature of 2000 F for 5 min. **Pressure Switch Div., Barksdale Valves,** 5125 Alcoa Ave., Los Angeles 58, Calif. L

Circle 693 on Page 19

Blower Wheels

are one-piece, molded-plastic units

Molded-plastic blower wheels are available in four diameters from 5⅜ to 8 in., either as single or double-inlet types. Of one-piece construction, wheels withstand elevated temperatures, are quiet in operation, corrosionproof, and lighter than steel units. Hubs can be located either inside or outside wheel. Standard stock bores are 1/2, 3/8, or 5/16 in. **Denbo Engineering & Sales Co. Inc.,** 3301 Martindale Ave., Indianapolis 18, Ind. J



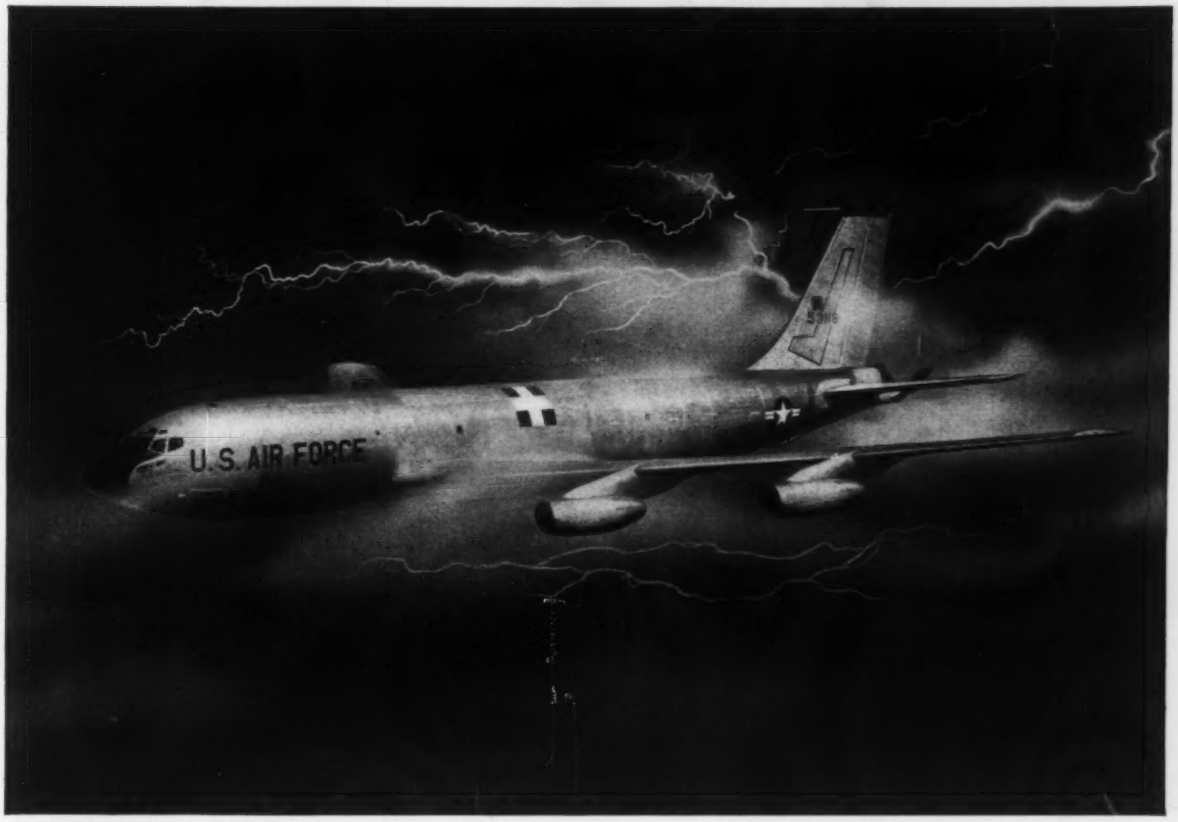
Circle 694 on Page 19

Cylinders

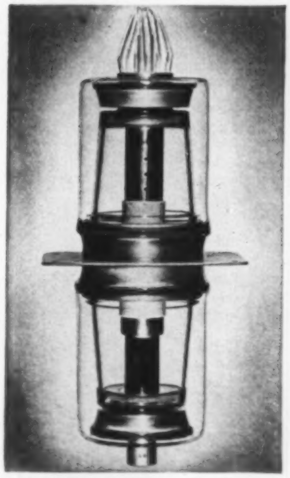
in single and double-acting types

Rovalve heavy-duty, single and double-acting air or low-pressure hydraulic cylinders are available in a variety of types. Square-head design with attachable mountings permits use of minimum space and allows mounting versatility. Self-regulating cushions eliminate impact between piston and cylinder heads. Square-head units are available in bores to 10 in. Round-head cylinders are supplied in 10, 12, 14, and 16-in. diameters. Standard

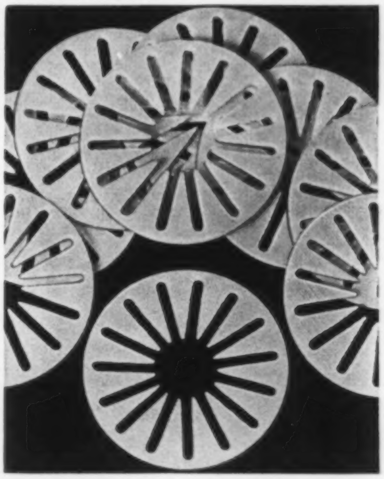
THE NATIONAL SCENE



BIG LIGHTNING HAZARD IN AIRCRAFT, flying through electrical storms, is the radio antenna. Metal skin and structural members insulate the ship against lightning. The antenna—insulated from the metallic skin—provides a path through which current can enter the plane. Simple spark gaps furnish some protection. But they cannot control long, cloud-to-cloud discharges and have never proved fully effective.



JOSLYN AND NATIONAL TEAM UP to tame lightning bolts. With an assist from National PHENOLITE, the Joslyn Aircraft Arrester eliminates lightning hazards—even at high altitudes. Attached to the plane's radio antenna, the arrester permits the flow of radio energy, but blocks lightning discharges and deflects them harmlessly.



PHENOLITE WINS IMPORTANT JOB. PHENOLITE silicone glass Grade G-7-830 forms the separator in the Joslyn Aircraft Arrester—holds essential metal spring contacts in position and acts as an arc barrier. For this, it must have unusual strength, good electrical characteristics, superior punchability—also be fungus proof and withstand severe vibration for long periods. PHENOLITE meets all of these requirements.

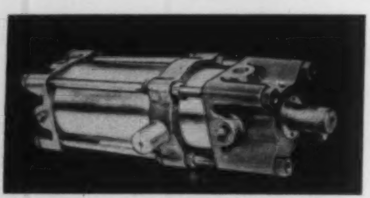
NATIONAL CAN HELP YOU

reduce unit product cost or improve product performance at no added cost. Here's why . . . You can select the "one best material" from over 100 grades of PHENOLITE®, Vulcanized Fibre and National Nylon—without compromise in properties or cost. You can simplify production and purchasing with the timed delivery of 100% usable parts—from a single reliable source. You gain competitively with National's new materials and grades—the direct results of programmed materials-research.

You benefit by calling National first. Check telephone directory Yellow Pages or write Wilmington 99, Delaware, Dept. G-2.

NATIONAL
VULCANIZED FIBRE CO.
WILMINGTON 99, DELAWARE
In Canada:
NATIONAL FIBRE COMPANY OF CANADA, LTD., Toronto 3, Ontario

Circle 530 on Page 19



cylinders to 16-in. diam operate on air, oil, or water pressures to 250 psi. Applications include plant and equipment automation. **W. G. Rovang & Associates Inc.,** 1945 N. Columbia Blvd., Portland 17, Oreg. M

Circle 695 on Page 19

Synthetic Rubber

has low nerve and shrinkage characteristics

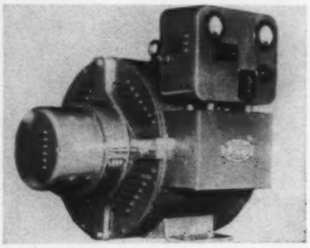
Chemigum N8 is a medium acrylonitrile content rubber especially applicable to extrusion and calendering operations. Exhibiting low nerve and shrinkage characteristics, it has excellent mill breakdown properties and accepts pigment readily. Substitution or blends of the material in existing compounds produces higher modulus and lower elongation. Rubber exhibits high hardness and compression set, and promotes smooth calendering, good mold flow, and excellent die reproductions. Applications include use in crash-pad skins, seals, rings, gaskets, industrial tubing and hosing, belts, and shoe soles. **Chemical Div., Goodyear Tire & Rubber Co.,** Akron 16, Ohio. F

Circle 696 on Page 19

Generators

in single and two-bearing types

Redesigned close-coupled 60-cycle generators can be adapted to commercial gasoline and diesel engines. Exciter endbell bearing has been eliminated, with exciter armature supported by main alternator bearing. Only one heavy-duty ball bearing is used, as drive end of generator is supported by engine. Two-bearing, close-coupled machines can also be supplied. Sleeve in armature fits over an extension of main rotor shaft, making unit lighter and more compact. Length of mounting feet has been reduced and use of four mounting feet has been eliminated, permitting accuracy and ease of alignment of generator to engine. Rating of the 60-cycle, three-phase line extends from 400 to 5000 w in revolving-armature type, and up to 400 kw in revolving-field type. **Kato Engineering Co.,** Mankato, Minn. J

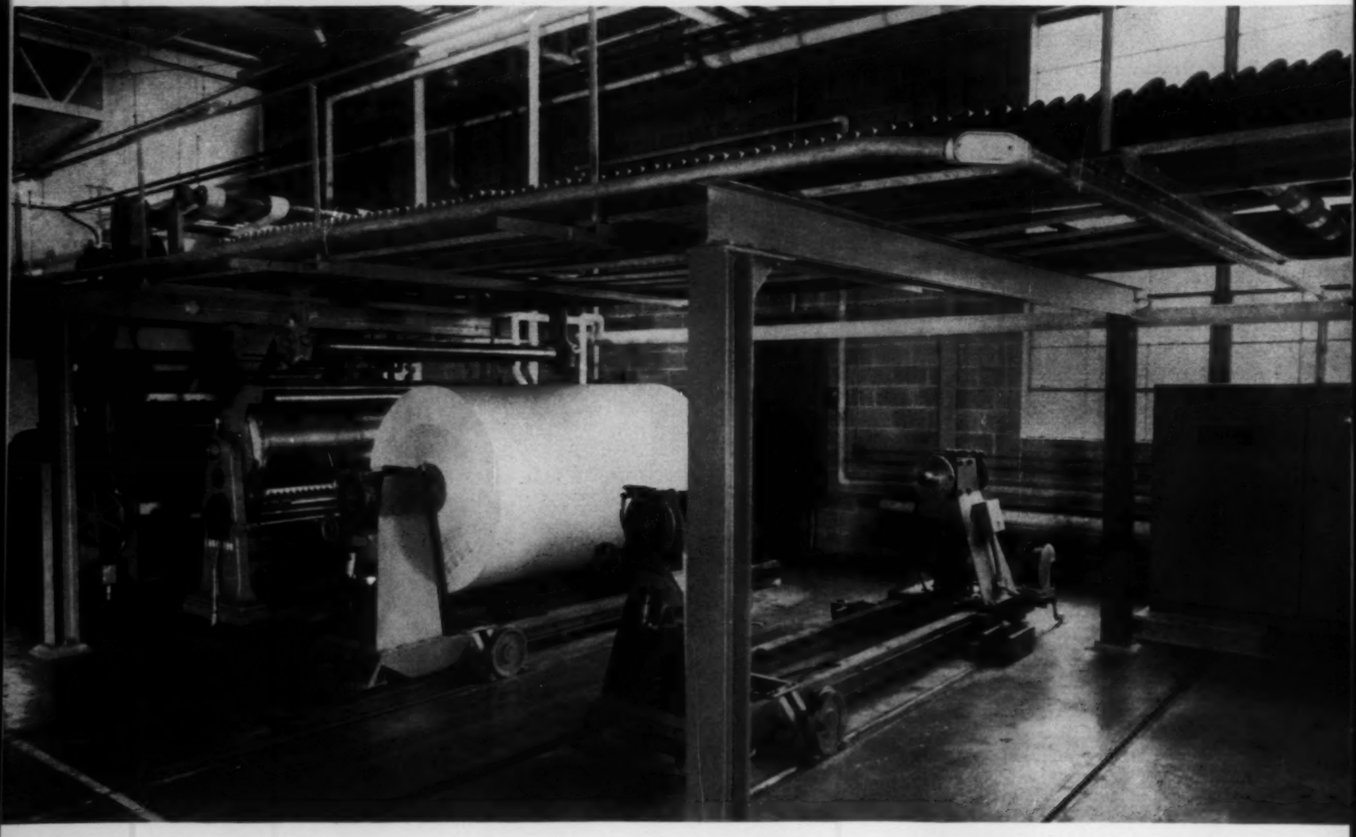


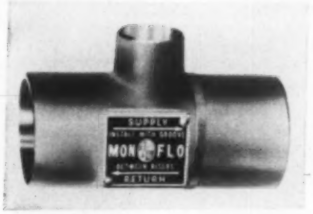
Circle 697 on Page 19

Fitting

for either supply or return

Red-Ring Monoflo one-pipe diversion fitting supplies radiation above or below the main. It can be used





for either supply or return. Unit is available in 1 and 1¼ in. copper. **Bell & Gossett Co.,** 8200 N. Austin Ave., Morton Grove, Ill. J

Circle 698 on Page 19

Silicone-Rubber Adhesive

bonds vulcanized silicone rubber parts

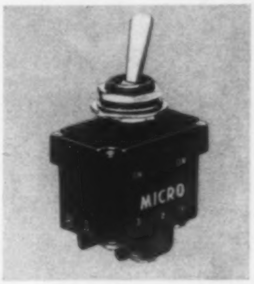
Easily applied, high-bond-strength silicone-rubber adhesive, identified as Silastic S-2200, is translucent, nontoxic, contains no solvent, and can be applied with knife or spatula. Designed to bond vulcanized silicone-rubber parts, it vulcanizes to create a strong bond in 5 min at 240-270 F. Adhesive is also used for bonding silicone rubber to a variety of common metals. Optimum adhesion to metal requires a cure of about 4 hr at 480 F under firm contact pressure. Parts can be assembled immediately upon application. Cured films develop strengths in the order of 25 lb pull per inch width and retain both mechanical strength and full resilience at temperatures from −70 to 500 F. Applications include splicing, gasket sealing, blanket mending, and duct lining. **Dow Corning Corp.,** Midland, Mich. H

Circle 699 on Page 19

Toggle Switches

for aircraft, railroads, and computer panels

New TL toggle switches provide integral terminals, high impact strength, and improved sealing. They are for use in aircraft, computer panels, and railroad equipment. Switches are available with all types of standard contact arrangements. Use of silicone seal between bushing and toggle lever, and nonhardening silicone sealant between cover and case prevents dust or moisture from entering chamber. Chromium-plated brass toggle lever has antirotation control, and plastic case resists carbon tracking from electrical arc. Switches include single, two, and four-pole units, rated 20 amp, 30 v dc, resistive. **Micro Switch, Div., Minneapolis - Honeywell Regulator Co.,** Freeport, Ill. K



Circle 700 on Page 19

Miniature Power Connectors

for heavy-duty applications

Series 250 Continental miniature power connectors are for aircraft and electronic equipment applications requiring high dielectric and

Westinghouse AV-DRIVE gives 10-second minimum to maximum corrugator capacity

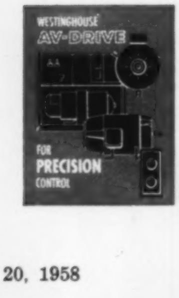
Smooth, controlled deceleration is provided by a Westinghouse AV-Drive for this corrugator at the Eddy Paper Corporation. Now this unit can be slowed from 600 to 60 fpm in as little as 10 seconds, while necessary changes are being made for another order.

After a year of almost constant operation, Westinghouse AV-Drives are still giving top-notch, trouble-free performance at this installation.

Do you have an adjustable speed drive problem? Call your local Westinghouse representative, or write Westinghouse Electric Corporation, 3 Gateway Center, P.O. Box 868, Pittsburgh 30, Pennsylvania.

J-22097

POWER-UP starts with CONTROL



YOU CAN BE SURE...IF IT'S Westinghouse

IT PAYS TO HAVE GOOD CONNECTIONS
HUBBELL

secure your product quality with HUBBELL premium miniatures

Here are the "tremendous trifles" upon which product quality depends. Hubbell miniature screws assure efficiency in your assembly operations, dependable product operation and long term product life and user satisfaction.

Hubbell miniatures are the finest obtainable. They are available in sizes #0 and #1 in steel, stainless steel or brass; and in head styles and sizes to meet your most exacting needs.

Hubbell quality can be your greatest production economy. If you have a special problem . . . call Machine Screw Department, Bridgeport, EDison 3-1181.

Even the PACKAGING PAYS OFF

New plastic "see through" boxes permit screw identification or inspection without opening the box.

Pressure-sensitive labels provide convenient identification by size and type; reseal the box securely after opening.

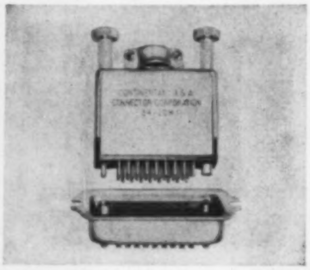
Sturdy "showcase" boxes stack easily, take up less room on storage shelves or work counters.

HARVEY HUBBELL, INC.
HIGHEST QUALITY
WIRING DEVICES • MACHINE SCREWS

OVER 60 YEARS' EXPERIENCE in the manufacture of highest quality, rolled thread machine screws and special cold headed parts.

MACHINE SCREW DEPARTMENT BRIDGEPORT 2, CONNECTICUT

Circle 532 on Page 19



mechanical strength. They are available in 20, 34, 50, and 75 contacts, with or without polarizing screwlocks. Contact terminations include solder cup for No. 16 AWG wire, turret, or taper pin for solderless wiring. Connectors meet MIL-C-8384 specifications. Electronic Sales Div., **DeJur-Amsco Corp.,** 45-01 Northern Blvd., Long Island City 1, N. Y. D

Circle 701 on Page 19

Pressure-Reducing Valves

for service to 200 F

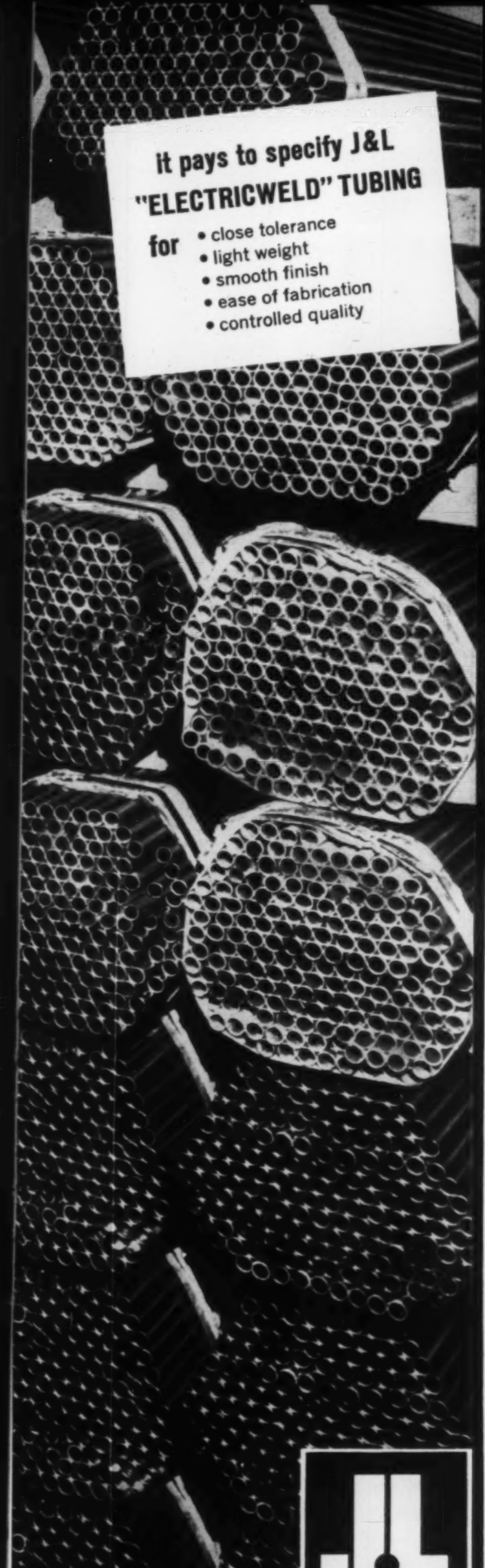
Type E-93 pressure - reducing valves have high capacity at a specifically desired setting. Suitable for service on either cold or hot water to 200 F, they are available in ½ to 2-in. pipe sizes. Valves are also suitable for air and other noncorrosive service, and for installations requiring high flow rates with accurately controlled pressure. **A. W. Cash Valve Mfg. Corp.,** P. O. Box 191, Decatur, Ill. I

Circle 702 on Page 19

Universal Joint Bushing

for steering-column use

Universal-joint, steering-column bushing is of nonwoven asbestos felt, compounded to produce desired friction ranges. Bushing is for use in the truck and farm im-


it pays to specify J&L
"ELECTRICWELD" TUBING
for
• close tolerance
• light weight
• smooth finish
• ease of fabrication
• controlled quality
J&L
STEEL

"Electricweld tubing gives us greater strength with lighter weight"

...says SHOPSMITH manufacturer

The Magna Power Tool Corporation has been using J&L's light wall tubing for Shopsmith ways since 1947. These twin tube mounts make possible the versatility of these popular multi-purpose home workshops. "Electricweld" precision tubing is used for the rigid straightness to .003" tolerance on diameter. Performance has been so satisfactory that Magna Power Tool Corporation now has eight applications for "Electricweld" tubing.

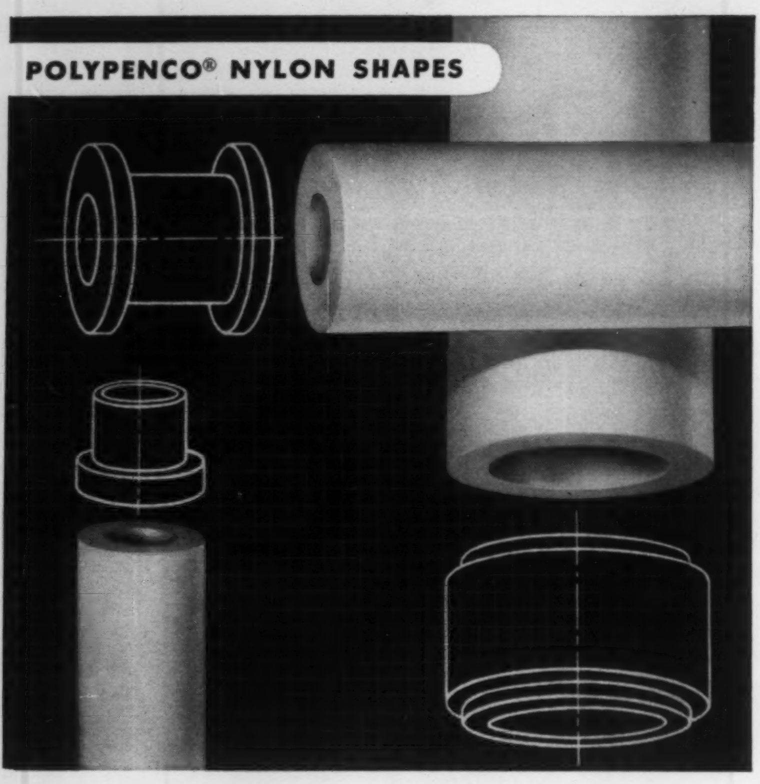
"Electricweld" tubing may be the answer to *your* design and manufacturing problems. Your nearby J&L representative can recommend the exact shape, size, gage and grade of tubing for your products. He frequently can reduce your costs, improve your product. Call him today, or write for information based on your specific requirements to Jones & Laughlin Steel Corporation, 3 Gateway Center, Pittsburgh 30, Pennsylvania.

Jones & Laughlin Steel Corporation

PITTSBURGH, PENNSYLVANIA

Circle 533 on Page 19

POLYPENCO® NYLON SHAPES



Design starts here . . .
with the proper nylon stock shape

• Here are tubular bars made of Polypenco nylon . . . produced to eliminate drilling operations, reduce stock costs per foot . . . manufactured under rigid controls to provide nylon with uniform density, controlled physical properties.

• Designers specify Polypenco nylon shapes because parts can be machined rapidly, at low cost, and to close tolerances . . . and because they have complete control over every phase of production, maintaining design flexibility.

Outstanding Properties

Nylon parts are wear resistant and resilient with an excellent strength to weight ratio. They provide low coefficient of friction requiring little or no lubrication—plus noise dampening and non-galling or abrasive characteristics. They resist most chemicals and have good electrical insulating properties.

Stock Shape with Wide Application

Polypenco nylon rod, tubular bar, strip and plate are available for quick conversion to parts such as gears, bearings, rollers, valve seats, thrust washers, wear strips, and many other applications in food and beverage industries, machine tools, etc. Stock is immediately available from warehouses throughout the country.

Fabricating Service

Custom fabricated parts are available from The Polymer Corporation of Pa., engineered for the best in design, quality and tolerances.

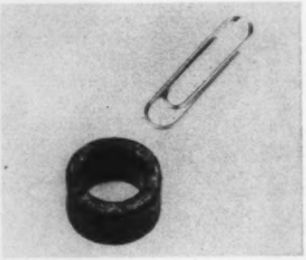
p POLYPENCO®

THE POLYMER CORPORATION OF PENNA.
Reading, Penna.
Export: Polypenco, Inc., Reading, Penna., U.S.A.

POLYPENCO nylon, POLYPENCO Teflon†, NYLAFLOW® and NYLATRON® GS †DU PONT TRADEMARK

Circle 534 on Page 19

plement field. It has an OD of 0.735/0.737 in., and length of 0.375 in. Applications generally specify four bushings per vehicle. **Equipment Sales Div., Raybestos-Manhattan Inc.,** Bridgeport, Conn. B



Circle 703 on Page 19

Temperature Control

has adjustable ranges between 0 and 425 F

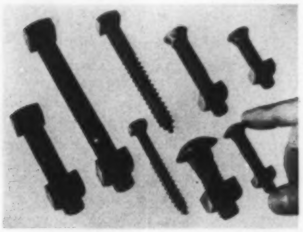
B95 explosionproof temperature control is for use in hazardous locations where explosive vapors or gases are present. Temperature settings are made by rotating a single-turn knob and pointer against a calibrated dial. Any one of three standard switches is available—normally open, normally closed, or double throw with no neutral position. Bellows, filled with a temperature-sensitive liquid, expands or contracts to activate a snap-action switch at desired preset temperature point. Unit is available with adjustable ranges between 0 and 425 F. **United Electric Controls Co.,** 85 School St., Watertown 72, Mass. B

Circle 704 on Page 19

Standard Bolts

in full range of sizes

Low-carbon steel standard bolts are available in a full range of sizes. Line consists of square head machine bolts, carriage bolts, lag



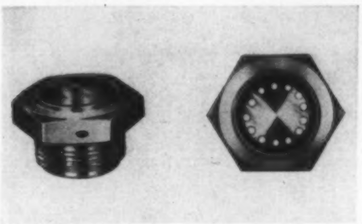
bolts, and plow bolts. Bolts of high-carbon and alloy steels, and departures from standard dimensions and types can be supplied on special order. **Cleveland Cap Screw Co.,** 4444 Lee Rd., Cleveland 28, Ohio. G

Circle 705 on Page 19

Oil-Level Indicator

for applications requiring quick visual inspection

Fluid level sight glass shows the presence of liquid by a reflecting surface located behind transparent window. Designed for applications that require quick visual inspection, it can be used to show the presence of oil in gear cases or to indicate liquid level in other types of housings. Reflector provides excellent visibility of fluid. When oil level changes rapidly within casing, level in sight glass tends to show a median location. **Technical Development Co.,** Glenolden, Pa. E



Circle 706 on Page 19

Metering Valves

for pressures to 3000 psi

PY 270 straight-pattern metering valves of Type 316 stainless steel have slow-rising stem which requires 20 complete turns to open or close valve. Valves are furnished with 1/16 or ⅛ in. orifice and ⅛ or ¼-in. NPT female connection. Lock nut for panel mounting is standard on all valves. Maximum operating

WORLD BESTOS
BRAKE LINING

. . . any *shape* . . . any *size* . . . any *friction*
to meet your most exacting requirements!

ROUND
as for Race Cars
INTRICATE
as for Industrial Brakes
TINY
as for small Precision Assemblies
BIG
as for giant Forming Presses

● World Bestos is currently helping many manufacturers solve difficult braking problems with special friction formulas that assure dependable stopping power, non-fading performance and extra long life.

World Bestos offers extensive research and development facilities and more than 30 years' specialization in friction material manufacture. Modern, high-capacity plant assures on-schedule delivery.

● Write for new Industrial Brake Folder . . . or let us know your specific requirements. Send prints and specifications if possible. Engineering assistance available.

WORLD BESTOS NEW CASTLE INDIANA

DIVISION OF THE
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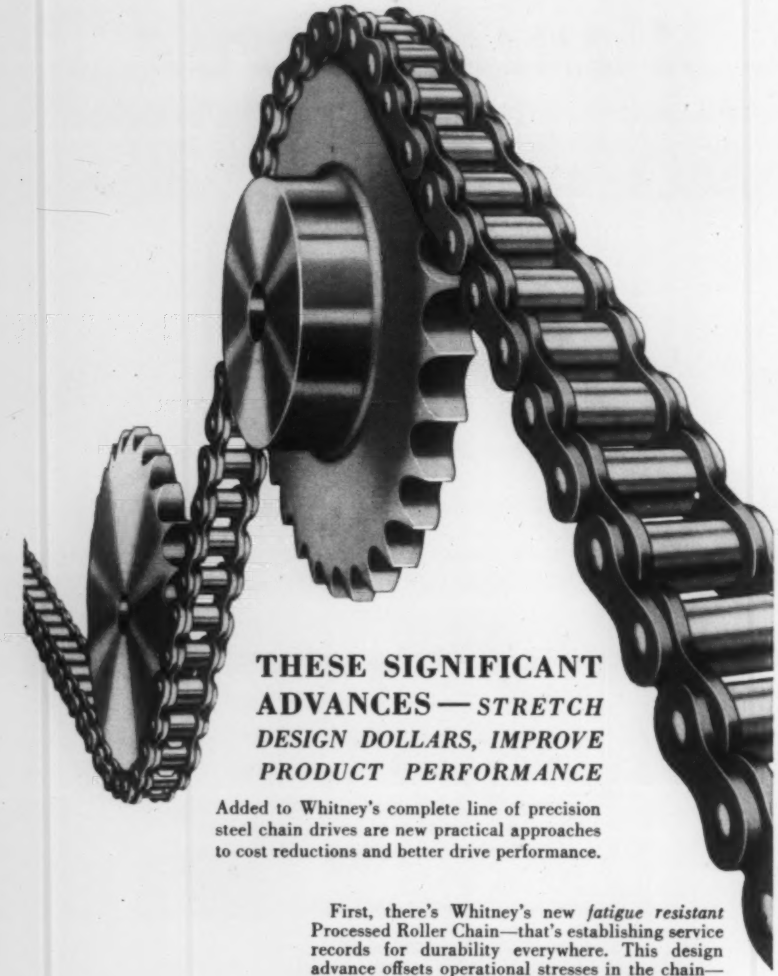
Industrial and Automotive Brake Blocks and Linings · Transmission Linings · Special Clutch Facings · Vibration Controls · Sheet Packing

Circle 535 on Page 19



THESE SIGNIFICANT ADVANCES—*STRETCH DESIGN DOLLARS, IMPROVE PRODUCT PERFORMANCE*

Added to Whitney's complete line of precision steel chain drives are new practical approaches to cost reductions and better drive performance.

First, there's Whitney's new *fatigue resistant* Processed Roller Chain—that's establishing service records for durability everywhere. This design advance offsets operational stresses in the chain—solves problems of heavy shock loads and severest operating conditions.

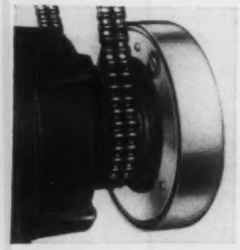
Then there's Whitney's Self-Lubricating Roller Chain—with sintered steel bushings that "oil from the inside"—are pre-lubricated for life. Ideal for installations where conventional chain lubrication may not be practical or desirable. Outlasts conventional chain as much as 5 to 1 in severe operating environments.

And if space limitations or weight are serious factors in power transmission, the new, *compact* Whitney High Capacity Roller Chain may be an effective solution.

Complete details on these design advances will be gladly supplied you.

Factory trained field engineers are available for practical recommendations on all of your chain and sprocket design problems.

Whitney Chain distributors and factory warehouses provide fast off-the-shelf service on a complete line of ASA roller chains, conveyor chains and stock sprockets.



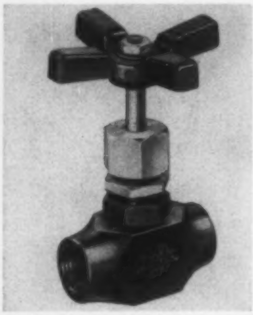
Heard About Whitney-Tormag Magnetic Drives? *For complete motor overload protection, cushioned starts and high efficiency, ask about our new permanent magnet, self-contained power transfer unit. Available in 1 and 2 H.P. units as stock items, additional sizes up to 15 H.P. will follow.*

Write for literature.

Whitney
CHAIN COMPANY
302 HAMILTON ST., HARTFORD 2, CONN.

ROLLER CHAIN • CONVEYOR CHAIN • SPROCKETS • FLEXIBLE COUPLINGS • WHITNEY-TORMAG DRIVE

Circle 536 on Page 19



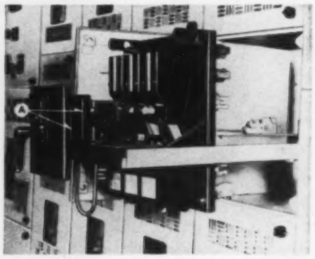
pressure is 3000 psi, and temperature range is −60 to 450 F. **Hoke Inc.,** 136 S. Dean St., Englewood, N. J. D

Circle 707 on Page 19

Air Circuit Breakers

with three-position breaker design

Type DB 600-v 15 to 4000-amp switchgear is a metal-enclosed unit which incorporates three-position breaker design. Door of breaker compartment can be closed with circuit breaker in any of the three recognized positions. Indication of breaker position is provided by two white lines (*A*) on mechanism. Trip action is accomplished by a separate pushbutton, protected on both sides by fixed guards. Guards are provided with slots, enabling padlocks to be applied to hold mechanism tripfree. **Westinghouse Electric Corp.,** P. O. Box 2099, Pittsburgh 30, Pa. F



Circle 708 on Page 19

Varnish

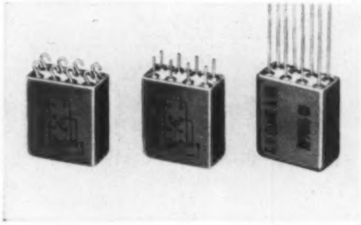
for coating electrical insulation components

R-610 silicone varnish has excellent retention of flexibility and original dielectric strength. Developed for coating and bonding Class H electrical insulation components, it contains 65 per cent silicone solids in xylene and has low viscosity. Properties include excellent penetration and wettability, fast drying time, adaptability to varying production conditions, high dielectric strength, low water absorption, and little weight loss due to curing and aging. Material can be used to bond mica tape, as an adhesive for bonding various other types of electrical insulation components, and also can be used in making thicker section laminates of these components where flexibility is needed. Varnish is available in 20-oz, 2-qt, and 1-gal bottles, and in 5 and 55-gal drums. **Silicones Div., Union Carbide Corp.,** 30 E. 42nd St., New York 17, N. Y. C

Circle 709 on Page 19

Hermetically Sealed Relay

withstands heavy shock and vibration



Type F hermetically sealed relay is rated for ambient temperatures from − 65 to 125 C. It meets shock of 50 g for 11 millisec. Contact rating is for 3 amp resistive at 28 v dc or 115 v ac. Terminal arrangements are suited to 1/10-in. grid spacing. Unit withstands heavy shock and vibration. **C. P. Clare & Co.,** 4101 Pratt Blvd., Chicago 45, Ill. I

Circle 710 on Page 19

Remote-Control Base

for adjustable-speed drives

Remote-control adjustable motor base, which regulates speed of adjustable-speed drives, is designed for use where motor-pulley drive is in an inaccessible location or where speed changes must be made or controlled remotely. Pushbutton control stations provide fingertip control for infinite speed adjustment throughout the speed range. Unit consists of a fractional-horsepower motor (available

Felt
has the Guts
to
"SNAP-BACK"!

No doubt about it — Felt by Felters is "teased" into just the right fiber arrangement for extra resiliency and long wear.

It does not crumble under pressure or deteriorate under continuous operation. Has predictable permanent set, is not adversely affected by age, water, oil, gasoline or acid in normal concentrations. It can be used with glass, wood, metal or plastics and treated chemically to meet technical and industrial requirements.

Respirator
DUSTS
BM 2254

FELT IN USE . . . Felt is widely used as filtering medium, from the respirator use shown here to filtering out impurities in oil and similar fluids. Felters Felt comes in variety of densities, has high absorption and is an effective, low-cost seal against dust and dirt.

Free Design Book

Find out about *all* the ways felt can help you in product design. Complete data in handy form, even to selection and ordering of right grades. It's yours for the asking. Send for it today: The Felters Company, 242 South Street, Boston 11, Mass.

Get the Best, Specify

FELT by FELTERS

Manufacturers of Felt and Felt Products *Represented in All Principal Cities*

Circle 537 on Page 19

MANY FACTORS CONTRIBUTE TO LOW INSTALLED COST OF SOUTHCO DRIVE RIVETS . . .

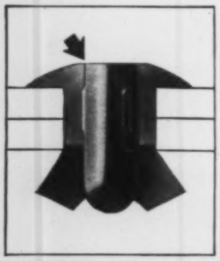
ECONOMICS OF FASTENING COVERS FULL CYCLE FROM INVENTORY REQUIREMENTS TO FINISHED PRODUCT

Designers who specify fasteners realize the many considerations that enter into cost determination. While ease of installation is often the most important feature, other factors affect costs. It may be difficult to put a dollar value on availability, for example, but serious financial losses do occur when production is held up or shipping dates are missed because of a slow fastener delivery. Being able to ship from stock, as Southco does, helps avoid production delays.

ELIMINATION OF SPECIAL TOOLS

Down time due to special tool failure and maintenance of special fastening tools are two fastening costs which are eliminated by Southco Drive Rivets. The only tool required is a hammer . . . any kind of a hammer . . . claw or ball, and size is not important. The number of men on a Southco riveting job is never limited by the number of special tools on hand and in working order.

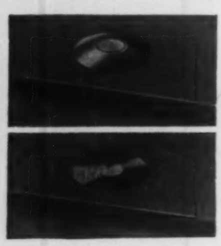
QUICKLY SET



To install, Southco Rivets are placed in drilled hole. The pin is then driven with a hammer. Installation is complete. No bucking is required.

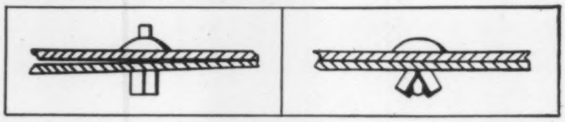
Expanded prongs force parts together. Pin is locked securely into rivet by displaced metal filling unique grooves. Compression forces are utilized for greater strength.

NO FINISHING OFF, NO WASTE



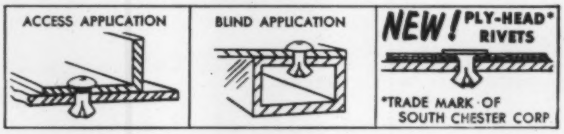
Impact of hammer seals pin neatly in rivet. No part of the rivet is cut off and discarded. No time-consuming filing, grinding or polishing is necessary. No scrap to clean up.

AUTOMATIC "PULL-UP" ACTION ASSURES TIGHT JOINT



Even when adjacent surfaces are separated, parts are forced together by Southco Rivet action, then held tightly in compression.

WIDE RANGE OF APPLICATION



*TRADE MARK OF SOUTH CHESTER CORP

Southco Drive Rivets are used to secure metal to metal or metal to wood. They are equally adaptable to blind or open applications. In each, they are quickly set and grip tightly. New PLY-HEAD* rivet permits higher loading of "soft" materials such as plywood, plastics and composition.

AVAILABLE IN ALUMINUM OR STEEL

Southco Rivets are supplied in aluminum or cadmium plated steel. The aluminum rivets have either cadmium plated or stainless steel grooved pins. The steel rivets have cadmium plated steel grooved pins.

Standard head designs are Universal or Countersunk. Full Brazier heads are available in popular sizes. New PLY-HEAD rivet rounds out line.

ALUMINUM

DIAMETERS	LENGTHS	NOMINAL GRIPS
1/8"	1/8" to 1/2"	1/32" to 13/32"
5/32"	7/32" to 3/4"	1/16" to 5/8"
3/16"	1/8" to 3/4"	1/32" to 5/8"
1/4"	7/32" to 3/4"	1/16" to 5/8"

STEEL

DIAMETERS	LENGTHS	NOMINAL GRIPS
1/8"	1/8" to 1/2"	1/32" to 13/32"
3/16"	1/4" to 3/4"	3/32" to 5/8"
1/4"	1/4" to 3/4"	3/32" to 5/8"

FREE FASTENER HANDBOOK . . . Send for your free copy of Fastener Handbook No. 7, just released. Gives complete engineering data on these and many other specialty fasteners. 52 pages, in two colors.

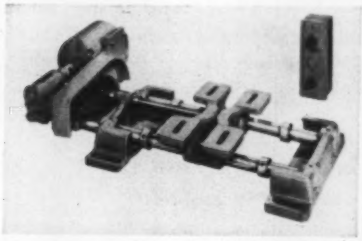
Write on your letterhead to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.

SOUTHCO FASTENERS
LION

©1957

BLIND RIVETS
¼ TURN FASTENERS
ADJ. PAWL FASTENERS
DOOR LATCHES
RETAINING SPRINGS
ANCHOR NUTS

Circle 538 on Page 19



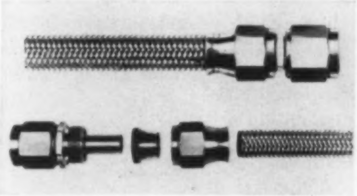
in single phase 110/220 and three phase 220/440 v), gear reducer, chain drive, and overload protection clutch. **Gerbing Mfg. Corp.,** 11800 Milwaukee Ave., Northbrook, Ill. J

Circle 711 on Page 19

Reusable Fitting

has triple locking feature

Seal-Lock reusable fitting is for use with high-temperature Teflon hose. Fitting incorporates a triple locking feature so that it is locked to hose and components are locked to each other. Two seals designed into the fitting are dynamically actuated by internal pressure. Left-hand assembly threads prevent loosening during installation. Flared skirt on socket protects hose from concentrated stresses. Straight and elbow couplings in sizes from − 3 to − 20 are available. **Resistoflex Corp.,** Woodland Rd., Roseland, N. J. D

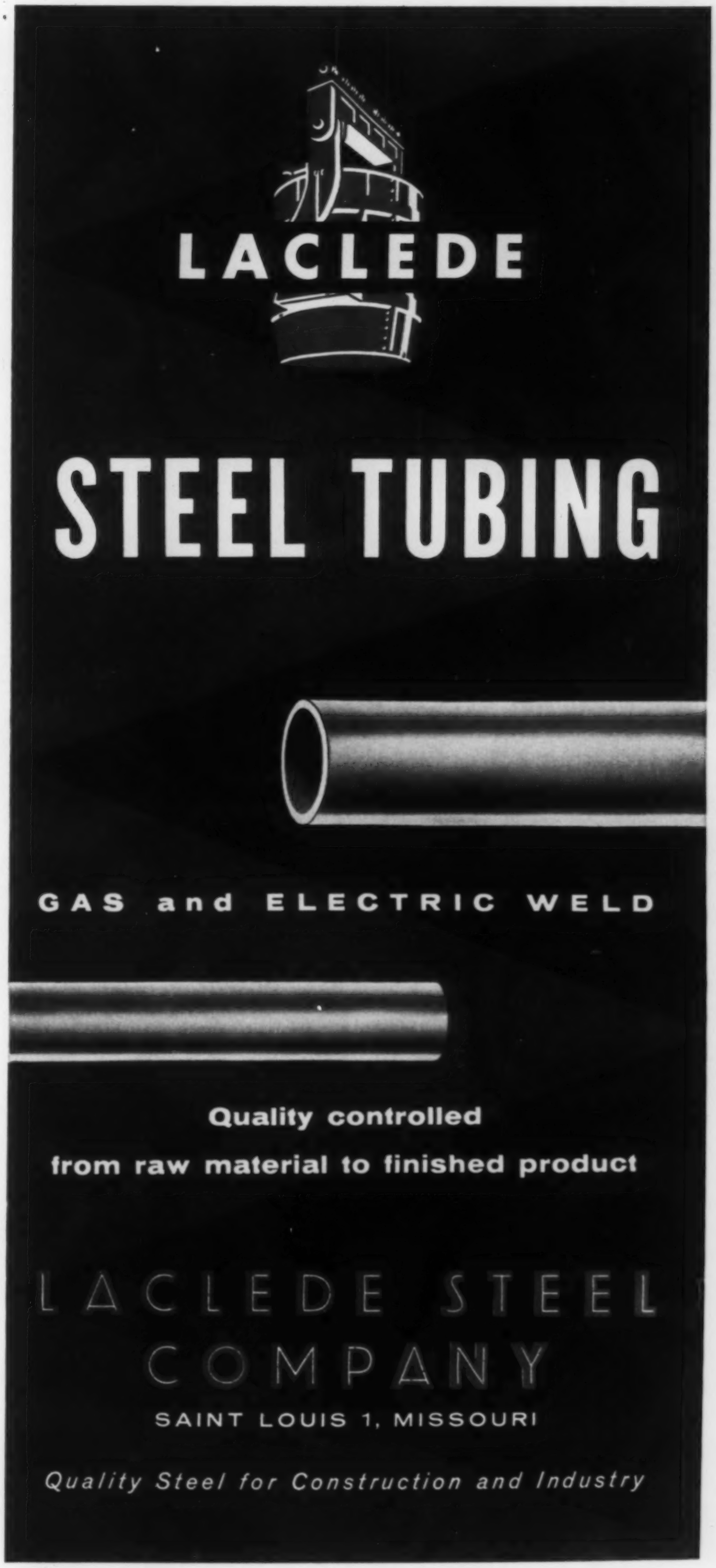


Circle 712 on Page 19

Film Adhesive

for flat-surface bonding of plastics and metals

Plymaster V-3 is 4-mil thick synthetic-rubber-resin film adhesive developed for bonding flat metal sheets, flexible plastic films to rigid and semirigid metals and plastics, and metal and plastic skins to honeycomb cores. Material incorporates high-strength, porous paper as the carrier for the latent adhesive. The solvent-free dry film adhesive is available in 36-in.



LACLEDE

STEEL TUBING

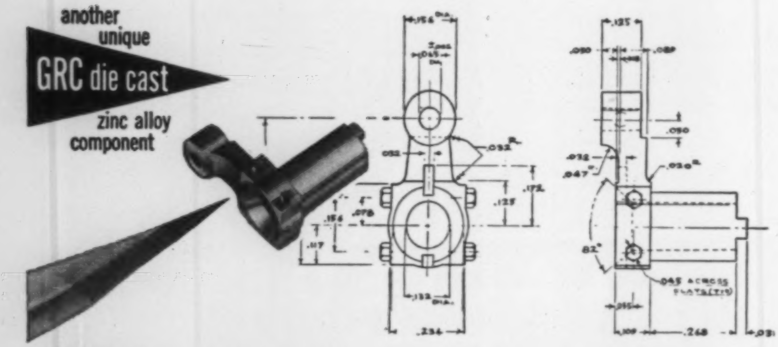
GAS and ELECTRIC WELD

Quality controlled
from raw material to finished product

LACLEDE STEEL
COMPANY
SAINT LOUIS 1, MISSOURI

Quality Steel for Construction and Industry

Circle 539 on Page 19



GRC die casting helps Lionel achieve tiny part authenticity

This intricate toy crank was die cast in zinc alloy by GRC in a single automatic operation. Cost? Little more than $5.00 per thousand in lots of 500,000. Result? Produced quicker and more economically than Lionel could themselves.

Less than half an inch overall, it is typical of the many small (maximum is 1¾" ½ oz., no minimum) parts problems solved by GRC's unique techniques. Gries' specialized machines deliver parts ready for use—uniform, accurate, clean—no trimming, no assembly, no scrap loss.

Write, wire, phone TODAY for detailed information, send prints for quotation.

World's Foremost Producer of Small Die Castings

GRIES

GRIES REPRODUCER CORP.

32 Second St., New Rochelle, N. Y., NEw Rochelle 3-8600

Circle 541 on Page 19

Design Guide to

Adjustable-Speed Drives

- ELECTRICAL
- MECHANICAL
- HYDRAULIC

$2.00 per copy

Here, in one book—148 pages, with 24 tables, 119 charts and 171 illustrations—is what the designer should know about adjustable speed.

(Remittance or Company Purchase Order must be enclosed with order.)

MACHINE DESIGN
READER SERVICE

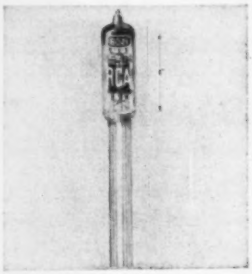
Penton Building
Cleveland 13, Ohio

width, in 100-yd and larger rolls, with protective interliner. **Rubber & Asbestos Corp.**, Dept. P, 225 Belleville Ave., Bloomfield, N. J. D

Circle 713 on Page 19

Subminiature Twin Triode

for use in mobile and aircraft equipment

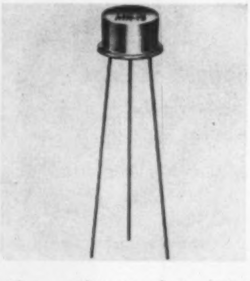


No. 6021 subminiature medium-mu twin triode is designed for oscillator and amplifier service in industrial and communications equipment operating at frequencies to 400 mc. Tube resists shock and vibration, and is suited for use in mobile and aircraft equipment. It can be operated at full ratings in altitudes to 60,000 ft without use of pressurized chambers. **Electron Tube Div., Radio Corp. of America,** 115 S. Fifth St., Harrison, N. J. D

Circle 714 on Page 19

Transistor

for military and industrial use



MN-19 germanium switching transistor is designed for high reliability requirements of military and industrial usage. Tests indicate the unit to be extremely stable, fast and reliable. It is available in large quantities. **Motorola Inc.,** 4545 W. Augusta Blvd., Chicago 51, Ill. I

Circle 715 on Page 19

Progress with TITANIUM

Giant autoclave *is divided into six inner compartments, each with a turbine impeller for agitating slurry, which contains cobalt, nickel, copper arsenic, iron and sulfuric acid, and iron-arsenic compounds. The reaction is carried out at pressures of 550-600 psi, at temperatures exceeding 400°F. The Calera Mining installation, at Garfield, Utah, was engineered by Chemical Construction Corporation.*

4TH BIRTHDAY FOR TITANIUM TURBINE

in corrosive slurry that quickly kills other metals

THIS encrusted, scale-covered turbine impeller made from Mallory-Sharon titanium is a thing of beauty to the cost-conscious Calera Mining Company. It's passing inspection after four years service in as corrosive an environment as you are likely to meet.

Calera oxidizes and leaches cobalt-arsenic-sulfide concentrates in a giant high-pressure, high-temperature autoclave. The autoclave, or pressure vessel itself is lined with acid resisting brick. But the turbines, piping, thermowells, and flange linings must be metal.

The piping, fabricated from Mallory-Sharon titanium, has seen continuous service—where alloy steels and nickel alloys failed in a matter of *hours*. Even on the hefty turbines, the longest service obtained was a *few weeks*—before titanium was fully specified for all turbine parts including fasteners. With flange linings and other parts the story is the same—titanium is the only choice from an economic standpoint.

Have *you* a corrosion headache that titanium can turn into a success story? We can help you evaluate this remarkable metal in your plant, supply engineering assistance, and deliver your sample or prototype requirements from stock. Call or write now for complete information.

MALLORY-SHARON

METALS CORPORATION • NILES, OHIO

Integrated producer of Titanium • Zirconium • Special Metals

Circle 542 on Page 19

To Get The Flexible Coupling Best Suited For Your Job...

Flexible Coupling Guide

use the Lovejoy Flexible Coupling Guide

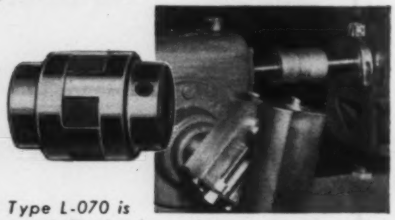
Save time, money and mistakes, insure trouble-free performance . . . by using the Lovejoy Flexible Coupling Guide. You'll get the exact type and size for your particular application —*plus all these Lovejoy features:*

- No lubrication required.
- Simple, rugged construction—few parts, no intricate mechanisms.
- No wear on metal parts—the load is transmitted through cushions only.
- Double-life cushions—one half the cushions act as idlers, except on reversing loads. Thus, a quick interchange provides a new set of cushions.
- Cushions engineered to load and service conditions.
- A maintenance-free coupling that is completely machined for ease and speed of alignment.

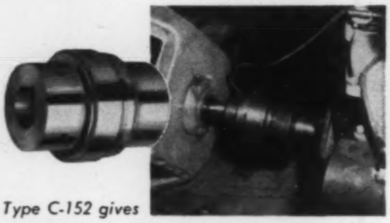
- **Act now! Send for your Flexible Coupling Guide today.**

LOVE-JOY
FLEXIBLE COUPLINGS

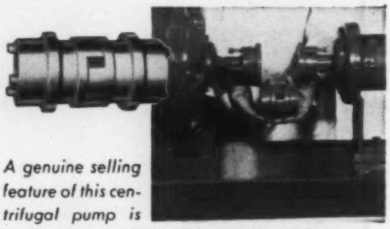
REQUEST CATALOG



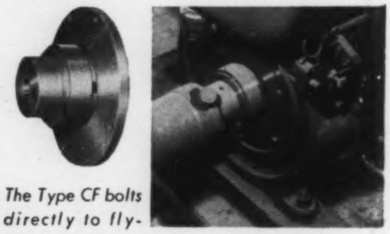
Type L-070 is exactly fitted to the requirements of this gear pump.



Type C-152 gives maintenance and trouble-free performance in a portable power unit.



A genuine selling feature of this centrifugal pump is the spacer type RRL which permits quick, easy disassembly without disturbing piping. (Courtesy Dean Brothers Pumps, Inc.)



The Type CF bolts directly to flywheel, reducing component requirements, cutting assembly time and providing a more compact unit.

LOVEJOY FLEXIBLE COUPLING CO.

4818 WEST LAKE STREET • CHICAGO 44, ILLINOIS

Circle 543 on Page 19

ENGINEERING DEPARTMENT EQUIPMENT

Template

contains all mathematical symbols

No. 17 mathematical symbols template contains all mathematical symbols, including small letters of Greek alphabet, parentheses, brackets, root symbols and integrals of varying size, numerals, and some of the capital Greek letters used in mathematical and chemical formulas. Template is 0.030 mathematical-quality plastic, with cut-outs precision milled. Size is 6¼ x 2½ in. **Rapidesign Inc.**, Box 429, Burbank, Calif. L

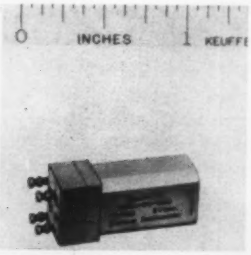
MATHEMATICAL SYMBOLS

Circle 716 on Page 19

Miniature Accelerometer

weighs only 7.2 grams

A52 linear accelerometer, approximately one-fifth the size of comparable instruments, has dimensions of 0.32 x 0.35 x 0.97 in. and weight of 7.2 grams. Unit is suited for use in missile guidance systems, within control surfaces for vibration studies on aircraft or missiles, within wind tunnel models, or in a variety of applications containing critical space limitations and requiring high accuracy. With output of approximately 32 mv full scale (open circuit) per 8-v exitation, unit has maximum allowable static acceleration of twice its rated range. Circuit of the instrument forms a complete balanced bridge with nominal resistance of 300 ohms. Utilizing the principle of the unbonded strain gage, accel-



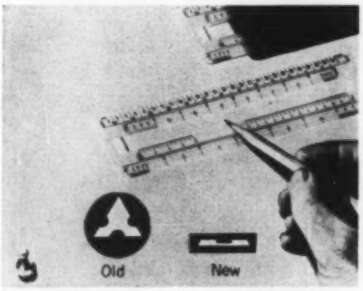
erometer can be used with dynamic measuring equipment without additional accessory equipment for amplification. **Statham Instruments Inc.,** 12401 W. Olympic Blvd., Los Angeles 64, Calif. L

Circle 717 on Page 19

Plastic Scale

shows eight scales on one side

New plastic scale contains all eight scales laid out side by side on one surface, rather than on three. Each scale has its own straightedge, calibrated to professional standards. Unit is of tough, clear acrylic, allowing scale calibrations to become comparative parts of print, plan, or schematic drawing. Six-inch, leather-sheathed pocket model and unsheathed 12-in. desk scale both carry graduations of 1/8, 1/4, 3/8, 3/4, 1/2, 1, 1½, and 3 in. to the foot. **A. Lawrence Karp,** 16 Putnam Park, Greenwich, Conn. B



Circle 718 on Page 19

Multiverter

transistorized unit gives voltage products

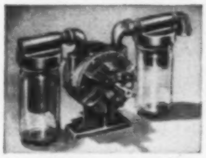
D Series completely transistorized multiverter, which has speeds in excess of 500,000 conversions per sec, generates a voltage that is the product of a digital number and either a fixed or varying reference voltage. If reference is an ac volt-

ROTARY AIR GAST PRODUCTS

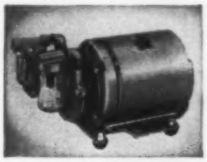
Model 3040 Oil-less Air Pump. Up to 20" vacuum, up to 10 p.s.i. pressure. Capacity to 24 c.f.m.

Provide oil-free air blast with any of the carbon-vane

GAST rotary vane AIR PUMPS



Model 0240, 0440, 0740 Series Oil-less Air Pumps. Three displacements, from 1.9 to 5.6 c.f.m. Vac. to 15", pressure to 10 p.s.i.



Model 0211-P103-G8X Integral-Motor Oil-less. Up to 1.3 c.f.m. Motor 1/6 h.p. Wt. only 22 lbs. Smaller Model 0406 Oil-less has 1/12 h.p.

Need a pump that delivers absolutely *oil-free* compressed air? A Gast Oil-less Air Pump may be your answer! Built in seven different models — vacuum or pressure — these pumps* run *entirely without oil* in the pumping chamber.

Four carbon vanes lubricate themselves. Ball bearings are grease-sealed for life and separated from pumping chamber by a ventilated space. Air flow can't be contaminated with hot oil vapor.

You can *forget* oiling maintenance problems too! Simple construction delivers up to 15,000 hours' operation without attention, depending on r.p.m. and service conditions. This is a big advantage, especially when your product requires a compressor or vacuum pump mounted in a hard-to-service location.

Widely used on food-packaging, paper-handling, folding and laboratory machines.

Write for full details — request Bulletins 152A and VP-356. GAST MANUFACTURING CORP., P.O. Box 117-P Benton Harbor, Michigan.

*Standard oil-lubricated models also available.

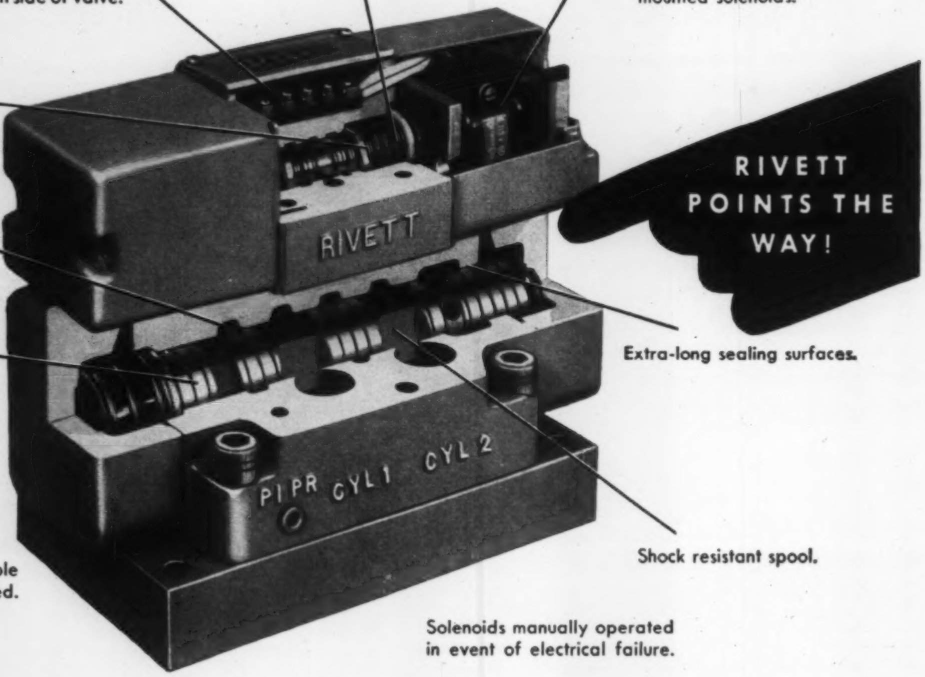
SEE CATALOG IN SWEET'S PRODUCT DESIGN FILE

GAST ROTARY

- AIR MOTORS TO 7 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

"Air may be your answer!"

Circle 544 on Page 19


Roomy wiring box with terminal strip. Dust sealed and moisture resistant. ½″ conduit connections on each side of valve.
Nylon push pin guide offers excellent bearing, long life.
Heavy, continuous duty, shock mounted solenoids.
Detent clip prevents piston from shifting.
RIVETT POINTS THE WAY!
Unrestricted passages allow greater flow capacity.
RIVETT
All surfaces precision ground.
Extra-long sealing surfaces.
PI PR CYL 1 CYL 2
Shock resistant spool.
Solenoids are inoperable when covers are removed.
Solenoids manually operated in event of electrical failure.

High Flow Capacity!

Rivett's New Solenoid Pilot Operated Hydraulic 1″ Valve Is Rated at 28 G.P.M. and the 1½″ Size At 82.5 G.P.M., At 15 Ft. Per Sec. Velocity.

- **Reduces Back Pressure, Friction, Heat**
- **Opens and Closes Smoothly, Positively**
- **Mounts In Any Position**
- **3000 P.S.I. Operation for Multi-Million Cycles**
- **Optional: Built-in Speed Controls Explosion Resistant Solenoid Enclosures**

Forget about back pressure by specifying Rivett 6600's for service up to 3000 P.S.I. Reduce inventory! Select off the shelf: 2 basic sizes fit ⅜″, ½″, ¾″, 1″, 1¼″ and 1½″ I.P.S. Single and double solenoid. 7 spool designs. Meet *all* J.I.C. requirements.

RIVETT, INCORPORATED • Dept. MD-2
Brighton 35, Boston, Mass.

THE BETTER YOU KNOW HYDRAULICS THE BETTER YOU LIKE

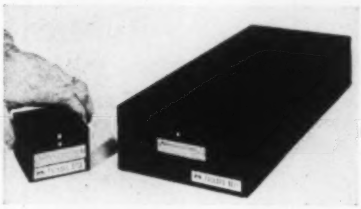
RIVETT
"100"
HYDRAULIC VALVES

Get Catalog No. 261 to aid your circuit design. Complete drawings, specifications, cut-away views, tables, diagrams!

Member National Fluid Power Association

Circle 545 on Page 19

age, generated voltage is ac; if reference is a fixed voltage, unit operates as a conventional digital to voltage converter. Completely solid state, unit has accuracy up to 0.01 per cent. Optional features include internal or external storage registers for digital values that accept either parallel or serial inputs, amplifier for applications requiring low impedance analog output, and internal or external power supplies. **Packard-Bell Computer Corp.**, 11766 W. Pico Blvd., Los Angeles 64, Calif. L

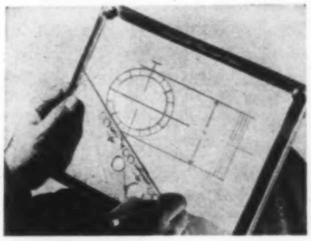


Circle 719 on Page 19

Drawing Board

is portable plastic unit

Graphostat portable plastic drawing board is equipped with two transparent plastic triangles which clamp to underside of board when not in use. Two retractable metal straightedges eliminate need for T-square. Four recessed spring clips hold standard 8½ x 11-in. sheet of paper. Rubber cushions protect desk top. Unit measures 10 x 12 in., and fits into briefcase. **Leslie Creations**, Dept. 863G, LaFayette Hill, Pa. E

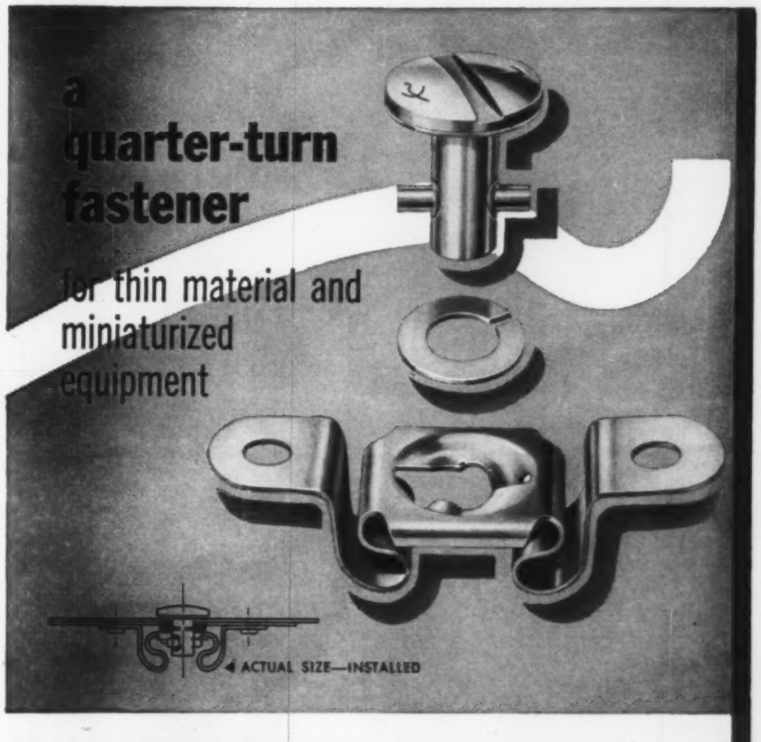


Circle 720 on Page 19

Drafting Pen

draws 1000-ft line without refilling

Riefler Grafika drafting pen permits the use of ordinary ink on any drawing surface. Rubber-base, fountain pen, colored or india inks, in addition to water colors, can be



CAMLOC *low cost/light weight*

5F series

Camloc's new small, lightweight 5F Series features high strength-weight ratio plus the quick-operating advantages of a ¼-turn fastener...in a size and weight that offers new design possibilities to original equipment manufacturers! Particularly adaptable to thin materials and miniaturized equipment like airborne electronics, small electro-mechanical and computing devices and communications components. Ideal for attaching lightweight components in "packaged" equipment or for holding access panels on everything from washing machines to radar units.

Offered in many different head styles. Complete specifications will be sent to you on request.

See Camloc products at the IRE Show March 24-27, Booths 4306 & 4308

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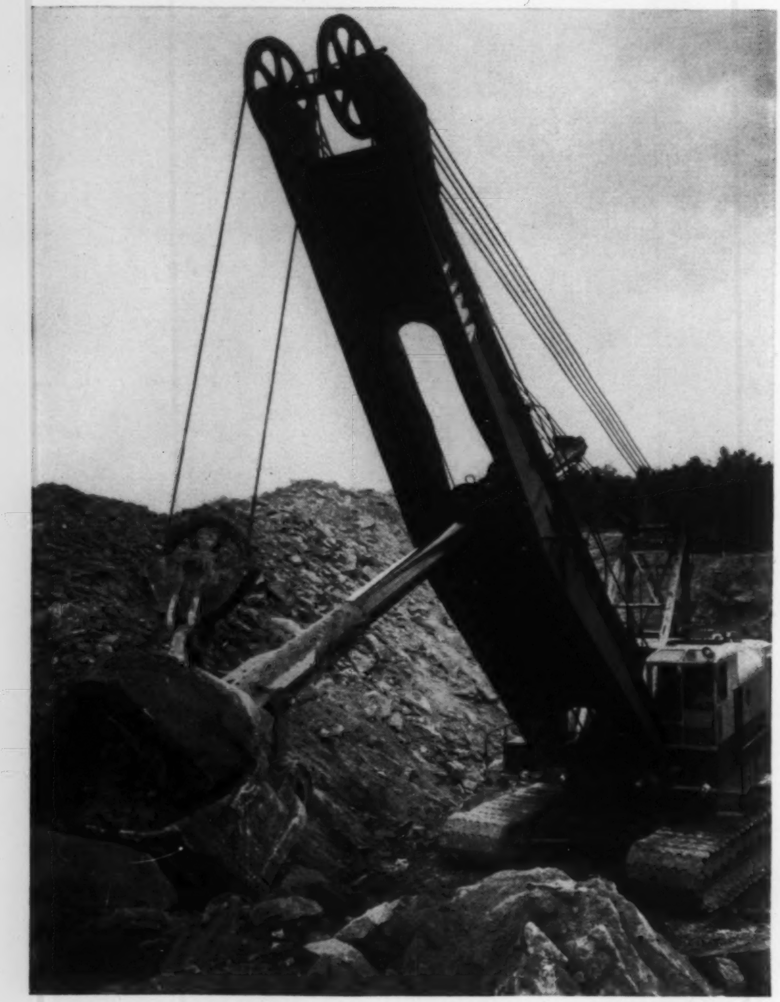
FORT WORTH OFFICE: 2509 W. BERRY ST., FORT WORTH, TEXAS

Circle 546 on Page 19



What happens when the bucket's moving rock like this?

The National Torque Converter gives the answer!

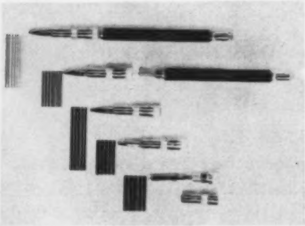
The bucket always wins the tug-of-war—because the shovel is equipped with a National Torque Converter. The Converter cuts crowding speed w-a-y down—and boosts crowding power way up!

The National Torque Converter not only automatically "tailors" the power delivered to the need, thus multiplying the useful workability of the machine . . . it also absorbs the damaging shocks that cause operator fatigue and equipment failure. If you build or operate any heavy equipment powered at from 100 to 1000 hp, National Torque Converters may improve its performance. Write:

THE NATIONAL SUPPLY COMPANY
INDUSTRIAL PRODUCTS DIVISION
Two Gateway Center, Pittsburgh 22, Pa.
Pace-Setters in the progress of industrial power transmission

Circle 547 on Page 19

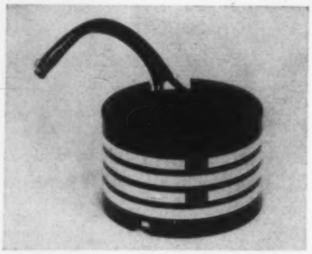
used with the pen on any medium, including paper, acetate, cloth, Mylar, or glass. Lettering attachments permit use of the pen with any type of lettering guide or template, or for a variety of free-hand work. Capillary-action ink control permits the proper amount of ink to be drawn from the reservoir, when pen is in contact with surface. Flow of ink ceases when contact with drawing surface is broken. Five interchangeable ruling nibs (shown) give a continuous range of line widths from hairline to 3/16 in. **Ozalid Div.**, General Aniline & Film Corp., 2 Corliss Lane, Johnson City, N. Y. D



Circle 721 on Page 19

Slip-Ring Assemblies
are custom constructed for rugged environments

Model R slip rings have silver conductors and pyrex glass inserts for circuit interruption embedded in a matrix of non-nutrient epoxy plastic reinforced with fiber glass. Model shown is designed for airborne operation and contains several channels. Conductors are rated for continuous operation at 20 ma, 300 v, with low noise level. Slip rings operate at temperatures from -60 to 160 F, and at altitudes from sea level to 60,000 ft. Vibration, shock, and other requirements of Mil-E-5272A are met. **Servonic Instruments Inc.,** 640 Terminal Way, Costa Mesa, Calif. L



Circle 722 on Page 19

THE ENGINEER'S

Library

Recent Books

Mechanical Vibrations. *By Austin H. Church, Professor of Mechanical Engineering, New York University; 275 pages, 6 by 9 in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, **$6.75** *postpaid.*

This book presents basic principles of vibration analysis which may be applied to a variety of problems not requiring advanced mathematics and extensive experience.

Vector methods and use of complex numbers are stressed. Topics covered include forced vibrations of multimass systems, harmonic analysis, torsional critical speeds, electrical analogies, coupling action, and balancing of angle or vee engines.

Association Publications

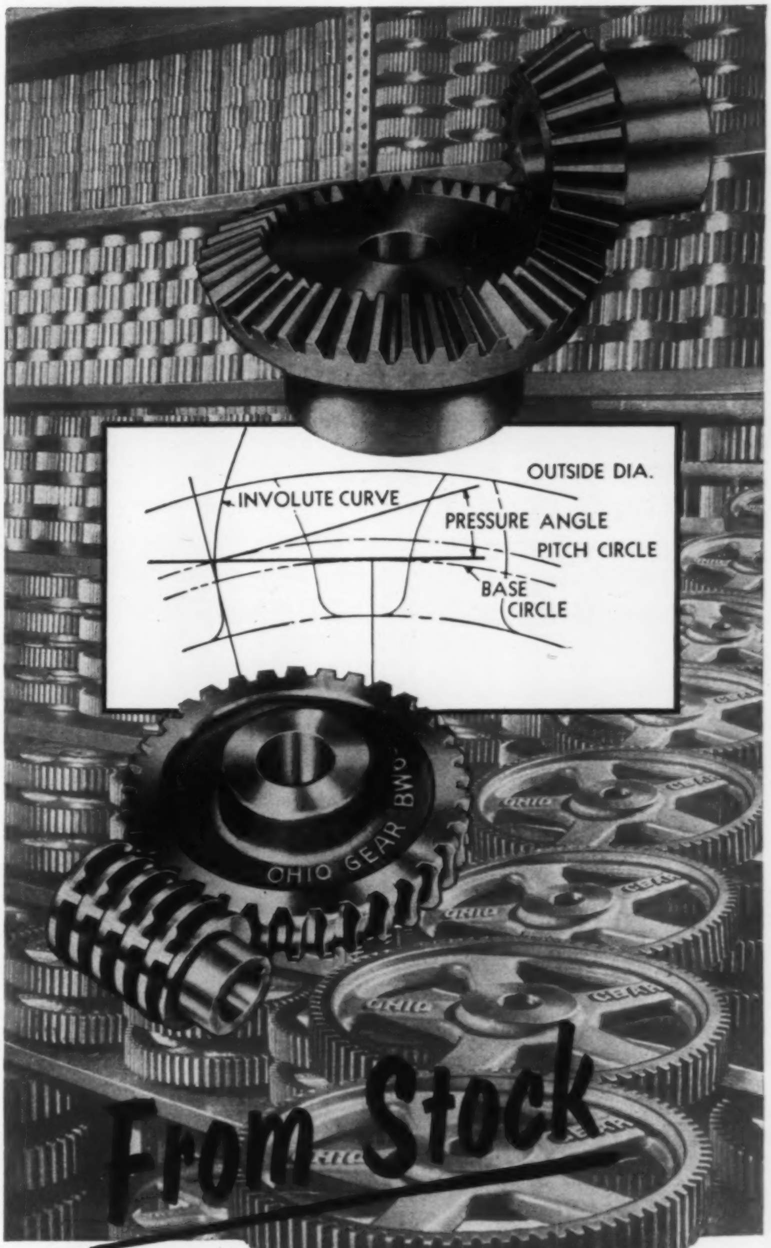
Metal Grating Handbook. *28 pages, 8½ by 11 in., paperbound; available from Metal Grating Institute, 1 Gateway Center, Pittsburgh 22, Pa.;* **$1.00** *per copy.*

This design manual contains schematic drawings, tables, installation photographs, and standards and specifications for many types of metal grating. A standard marking system correlates type of grating, size of bearing bar, bearing-bar spacing, and cross bar or rivet spacing.

Also included are load and deflection tables, conversion factors, design practices and codes, grating applications, and glossary of terms.

Metal Cutting Tool Nomenclature. *107 pages, 8½ by 11 in., paperbound; published by and available from Metal Cutting Tool Institute, 405 Lexington Ave., New York 17, N. Y.;* **$4.50** *per copy.*

This book contains terms and definitions pertaining to metal-cut-



14½° and 20° Pressure Angle Gears

All Ohio Stock Gears have a generated tooth form for stronger, quiet, and smoother running performance. AVAILABLE in 14½ DEGREE OR 20 DEGREE PRESSURE ANGLE. Spur gears, 3 to 64 Pitch; worm gears, 3 to 32 Pitch; bevel gears, 3 to 16 Pitch; miter gears, 4 to 32 Pitch; helical gears, 6 to 24 Pitch.

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Circle 548 on Page 19

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HOT PROBLEMS
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VULCAN
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Company ____________
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Circle 549 on Page 19

ting tools and their elements. These terms and definitions were selected and standardized by the Metal Cutting Institute as being the most descriptive and conforming best to common usage.

Definitions, illustrations, and nomenclature are arranged in separate sections for various classes of tools such as twist drills, reamers, counterbores, taps, dies, milling cutters, and broaches.

Manufacturers' Publications

Kaiser Aluminum Bus Conductors Technical Manual. 168 *pages,* 8½ *by* 11 *in., clothbound; published by and available from Technical Publications Dept., Kaiser Aluminum & Chemical Sales Inc.,* 919 *North Michigan Ave., Chicago* 11, *Ill.; book is available without charge if requested on company letterhead; otherwise,* $7.50 *per copy.*

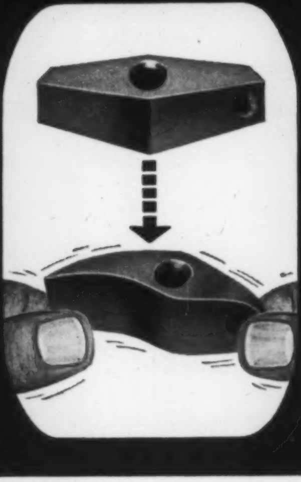
This book illustrates, describes, and classifies the numerous aluminum bus bar shapes and alloys which are now available. Major topics include alloy characteristics and properties, conductor shapes, manufacturing processes and tolerances, electrical and mechanical design criteria, methods of joining conductors, and a special section of tables and specifications.

New Lessons in Arc Welding. 320 *pages,* 5½ *by* 8½ *in., clothbound; published by and available from The Lincoln Electric Co., Cleveland, Ohio;* $1.00 *postpaid in U. S. A.,* $1.50 *elsewhere.*

This second edition has been rewritten and reorganized to include information on new procedures, machines and electrodes. Based on arc-welding courses taught at the Lincoln Arc Welding School and experience of other arc-welding teachers, it is a practical text for teaching arc welding in vocational, trade, and industrial courses, and a reference book for welders, supervisors, and others using arc welding in industry.

The book is divided into seven sections, the first dealing with specific instructions on arc-welding techniques and related welding information. Five sections pertain to proper use of welding machines

just to *stretch*
a point.



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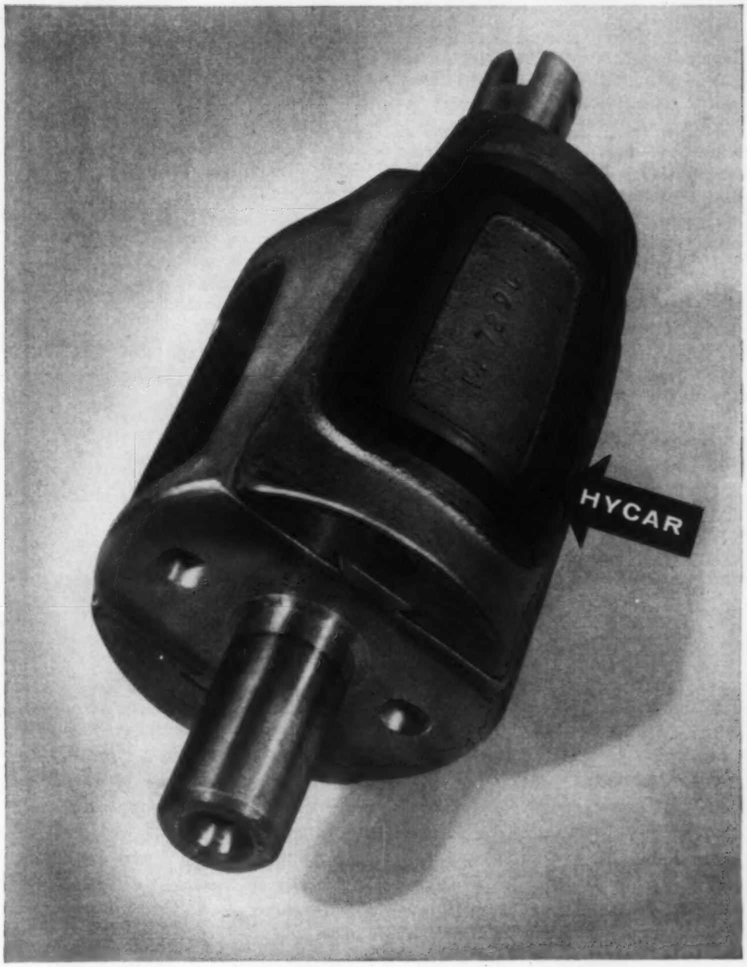
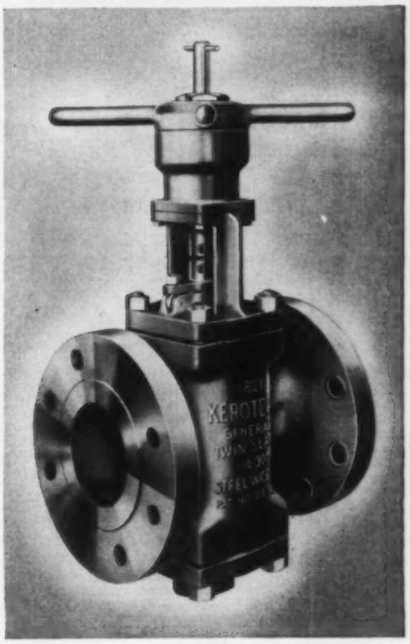
Circle 550 on Page 19

Another new development using

B.F.Goodrich Chemical *raw materials*



This Kerotest General Twin-Seal plug-type valve made by Kerotest Manufacturing Company, Pittsburgh, has two "slips" as seating surfaces with Hycar bonded to them. They are retracted when valve is opened, expanded when valve is closed to provide positive, vapor-tight seal. Hycar face slips are made and bonded by Castle Rubber Company of East Butler, Pa. B.F.Goodrich Chemical Company supplies the Hycar rubber material only.



Hycar makes valves seal vapor-tight

CARRYING and controlling hard-to-handle gases and chemicals calls for valves that seat securely. This new plug valve uses Hycar rings bonded to its "slips" to assure a vapor-tight shutoff.

Hycar nitrile rubber is ideal in applications like this. Its outstanding resilience means that it can withstand repeated and severe mechanical deformation. Since it lives with hydrocarbons that would destroy other types of rubber, it can be used for natural gas, distillate, and sweet and sour crude oil. And it will stay flexible under temperature variations.

Hycar may be the material that will help you get more results out of your product. For technical information, write Department KK-1, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

Hycar
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B.F.Goodrich **GEON polyvinyl materials • HYCAR American rubber and latex • GOOD-RITE chemicals and plasticizers • HARMON colors**

Circle 552 on Page 19

2¹¹⁄₁₆"
2¹³⁄₃₂"
4⁷⁄₁₆"
3¹¹⁄₃₂"
6½"
8¼"
AH
START
STOP
COMPACT DESIGN
RUGGED DEPENDABLE CONTROL

MANUAL STARTERS

WITHOUT OVERLOAD PROTECTION
TYPE "NF"
Weight—1½ lbs.

WITH OVERLOAD PROTECTION

TYPE "RT" *Weight 5 lbs.*

COMPACT... ECONOMICAL COMPLETE LINE

Type "NF" Manual Starters... toggle-operated, without overload protection... are *compact*, and completely dependable. Rated to 30 Amp., 2 hp capacity at 600 volts. Available in 2, 3 or 4 poles.

Type "RT" Manual Starters... push button operated, with overload protection... are *small* and reliable. Control single and polyphase motors up to 7½ hp, 600 volts. Available in sizes 0 and 1.

Both "NF" and "RT" types supplied with general purpose, weatherproof or explosion-proof enclosures. Arrow-Hart's complete line also includes manual starters, without overload protection, for reversing and two-speed applications... and toggle action switches for other manual starter applications.

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Circle 553 on Page 19

ARROW AH HART

and electrodes, and a final section is devoted to reference material on metals, procedures, testing and weld symbols.

Government Publications

Ultrasonic Welding of Metals, PB 131084. *By J. B. Jones, C. F. Deprisco and J. G. Thomas, all of Aeroprojects Inc., West Chester, Pa.; 89 pages, 8½ by 11 in., paperbound; available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.; $2.75 per copy.*

This report covers improvements made in ultrasonic welding equipment and techniques in relation to joining similar and dissimilar metals. Studies were made with 1100 Al to determine effects on weld strength of oxide film thickness, cold work, grain orientation, surface condition, and post annealing. Corrosion resistance of ultrasonically welded 1100 Al in two environments was evaluated.

Results indicate a range of materials and sheet thicknesses which can be bonded successfully by ultrasonic welding. Also covered are techniques of joining metals of different thicknesses which are difficult or impossible to join by other welding methods.

Effects of Rubber Compositions, Rubber Chemicals, and Plasticizers Upon Polyethylene, PB 131091. *By S. Axelrod, Picatinny Arsenal, Dover, N. J.; 15 pages, 8½ by 11 in., paperbound; available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.; 50 cents per copy.*

This report covers a study to determine effects of rubber formulations on mechanical properties of polyethylene. Since both polyethylene and rubber are frequently used together in assemblies, an attempt was made to classify constituents of rubber formulations which may adversely affect serviceability of polyethylene by prolonged contact.

U. S. Research Reactors. *Prepared by Battelle Memorial Institute; 73 pages, 8½ by 11 in., paperbound; available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.; $1.50 per copy.*

This book presents a compilation of data on more than 30 research reactors in actual operation or under construction at various installations. These have been selected as representative of U. S. development.

Reactors are grouped according to major types, and one or two of each type are described in detail as examples. Data on each installation include power, fuel, heat transfer, nuclear factors, control rods, shield, experimental facilities, and cost. Detailed construction drawings are included.

A complete listing of U. S. research reactors constructed, being built, or in the planning stage is also included.

OTS Research Reports. *Each publication is 8 by 10½ in., paperbound, and side-stapled; copies are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.*

The following reports are available:

PB 111849. Research and Development for the Welding of Titanium and Titanium Alloys. By

J. J. Chyle and I. Kutuchief; 77 pages, $2.00 per copy.

PB 111850. Research and Development on the Welding of Aluminum Alloy Plate. By J. J. Chyle and I. Kutuchief; 65 pages, $1.75 per copy.

PB 111996R. A Second Survey of Domestic Electronic Digital Computing Systems. By M. H. Weik; 439 pages, $7.00 per copy.

PB 121026. Development of Lean - Alloy Chromium - Nickel Stainless Steels for High-Temperature Use. By J. Salvaggi and G. J. Guarnieri; 81 pages, $2.25 per copy.

PB 121424. On the Theory of Replacement of Machinery with Random Failure Time. By G. H. Weiss; 26 pages, 75 cents per copy.

PB 121662. A Handbook on the Properties of Cold-Worked Steels. By L. J. Ebert; 85 pages, $3.00 per copy.

PB 121725. Vapor Deposited Coatings. By L. Schetky, H. S. Spacil, and J. Wulff; 39 pages, $1.75 per copy.

PM 121736. Heat Resistant Paints for Rocket Launchers. By T. Rice; 11 pages, 50 cents per copy.

PB 131110. Room-Temperature Tensile Properties of Several Titanium Alloys After Being Heated in Argon at Temperatures of 1400-1800 F. By W. H. Duffy; 33 pages, $1.00 per copy.

PB 131118. The Influence of Forging Temperature on Mechanical Properties of Al-V Titanium Alloys. By L. S. Croan and F. J. Rizzitano; 24 pages, 75 cents per copy.

Effects of Radiation on Nonmetallic Materials. *By E. L. Mincher; 38 pages, 8 by 10½ in., paperbound; available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.; 35 cents per copy.*

Effects of high-intensity gamma radiation on organic liquids, lubricants, plastic laminates, enameled magnet wire, insulating tapes, and inorganic thermal insulation are covered in this report.

Wright Air Development Center Technical Reports. *Each publication is 8¼ by 10¾ in., paperbound, and stapled; copies are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.*

PB 121191. Investigation of Thermal Properties of Plastic Laminates, Cores, and Sandwich Panels. 69 *pages;* $2.00 *per copy.*

This report presents thermal-conductivity, specific - heat, and thermal-expansion values for (1) four glass-fabric laminates with the same reinforcing fabric but with different resins, (2) four foam-plastic cores, (3) one foam sandwich panel, and (4) one honeycomb panel.

PB 131026. Evaluation of the Engineering Properties of Titanium Carbide Base Cermets. 60 *pages;* $1.75 *per copy.*

This report presents results of a program to evaluate various recently developed compositions of titanium carbide cermets under high-temperature conditions.

MOTOR CONTROLS

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Rugged Size 4 Magnetic Starters

Compact, lightweight Arrow-Hart fully designed Size 4 Magnetic Starter (*smallest size 4 on the market*) provides maximum performance in minimum space. This is made possible by A-H's advanced "RA" (Right Angle) design. Other features add up to dependability . . . *perfect guided alignment* for positive, uniform contacting . . . a *straight thru wiring* that simplifies circuit design, installation and servicing . . . *sturdy contacts* with silver alloy tips. Sizes 0 through 5 Magnetic Starters offer comparable advantages.

Write on company letterhead for 8-page folder on Size 4 Starter and other engineering data on Sizes 0 through 5 to The Arrow-Hart & Hegeman Electric Company, Dept. MD, 103 Hawthorn Street, Hartford 6, Connecticut.

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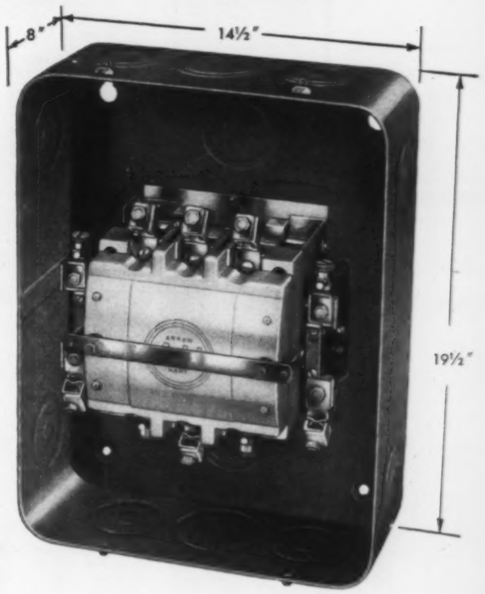
TYPE "RA"

Weight 56¼ lbs.



Circle 554 on Page 19

MECHANICAL ENGINEERS
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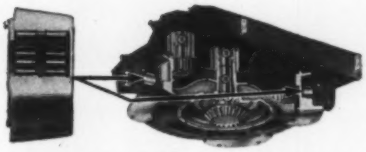
GUIDEROL® bearings add efficiency – and sealing – to greater capacity

for THEW LORAIN

McGill bearings have the proven quality, design advantages, extra capacity and precision required to insure the efficiency of needle type roller bearings in all modern machinery. They are specified by Thew Lorain to help make the performance of their giant 75 ton Moto-Crane smooth, rugged and reliable under severe operating conditions. Thew Lorain specifies McGILL bearings in all heavy duty equipment for their outstanding dependability with reduced maintenance. McGill bearings will work equally well for you. Write for Catalog No. 52-A.

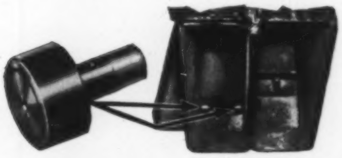


Special GUIDEROL® bearings for turntable rollers

Four of these specially designed turntable rollers support the entire weight of the superstructure plus overhanging work load. They replaced inadequate plain friction rollers to allow for smoother handling of even greater imposed loads with no track wear. Simplified lubrication and longer life reduced maintenance.

Sealed GUIDEROL® bearings for boom peak sheave

The integral seal design of these extra capacity bearings offers exceptional compactness in the Jib and Boom Peak sheaves. Unit costs are lower because counterboring for separate closures are unnecessary. Retained grease in the protected bearings eliminates climbing or lowering the boom for frequent relubrication.



Sealed CAMROL® Cam Followers for outrigger support

Located in the outrigger carrier channels, these cam follower bearings facilitate extending the supporting outriggers. Subject to heavy working loads, these sealed bearings provide low cost and dependable anti-friction support rollers that stay clean and well lubricated.

Sealed GUIDEROL® bearings for fairlead sheave

Fairlead sheaves at the base of the boom on drag lines and back hoes, etc. need bearings protected from contamination. Effective sealing against ever present dirt and grit materially extends bearing life.

Insure performance with McGILL®

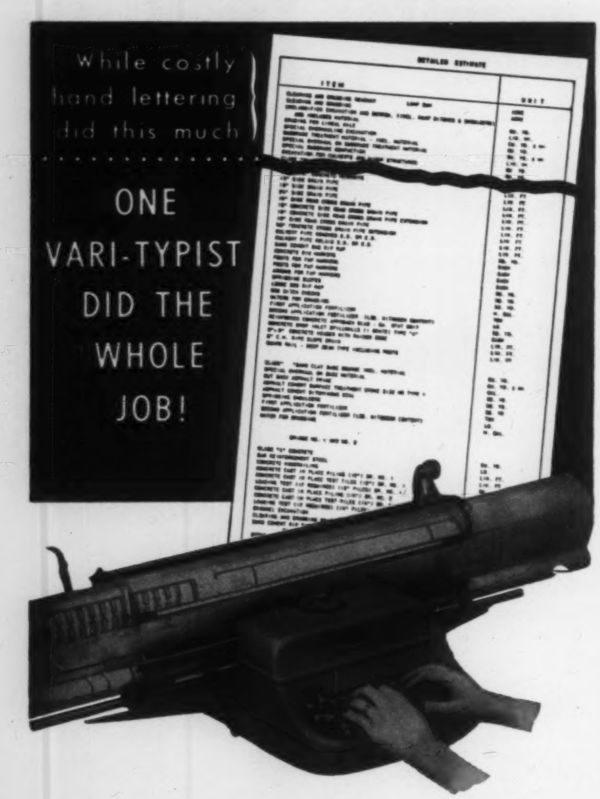
MULTIROL® GUIDEROL® CAMROL®

Precision Needle Bearings

McGILL MANUFACTURING COMPANY, INC., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

Circle 556 on Page 19

1 Vari-Typer saves the lettering time of 4 draftsmen!


While costly hand lettering did this much
ONE VARI-TYPIST DID THE WHOLE JOB!

Why waste your high-priced draftsmen on simple lettering jobs when your office typist, using the Vari-Typer, can do these jobs 4 times faster.

Vari-Typer Model E-24 with hundreds of instantly changeable type faces, is especially designed to give clean, crisp lettering on tracings (cloth or paper) even 12 feet or more wide!

Here is a simply operated, cost-saving lettering machine ideal for lettering on specification sheets, bills of material, instruction manuals, and forms. Type fonts are available with engineering and mathematical symbols.

Vari-Typer is currently saving thousands of draftsman hours in many of the world's leading industrial and engineering organizations. Ask your nearby Vari-Typer man for a free demonstration or write direct for information.

Text of this advertisement was composed on a Vari-Typer. (Headlines by Headliner).

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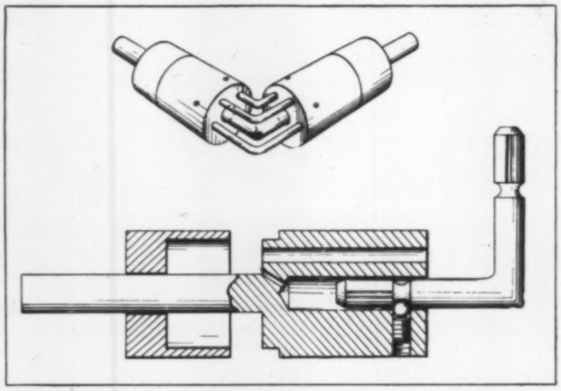
Circle 557 on Page 19

NOTEWORTHY

Patents

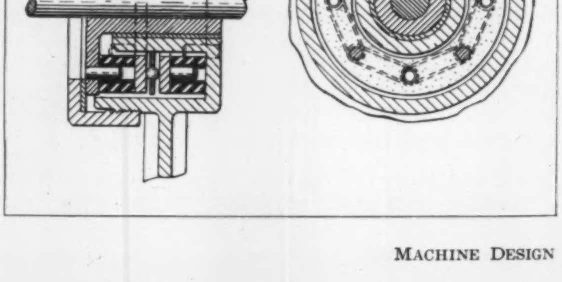
Right-Angle Coupling

Power is transmitted around a corner by multiple rods reciprocating in a right-angle coupling designed as a substitute for mitre gears. Heavy central rod, which does not rotate, maintains driving and driven coupling heads in accurate alignment. Operating with minimum backlash, noise, and vibration, the unit incorporates a lubrication reservoir to insure long service life. *Patent* 2,811,025 *assigned to Flexi-Versal Corp., Peoria, Ill., by Leslie J. Redard.*



Torque-Limiting Pulley

Breakaway torque is adjustable in a torque-limiting pulley. Coupling of driving and driven pulley elements is through multiple balls which engage an opposing pair of annular rings with cam-contoured faces. During overload condition, elastomer backup

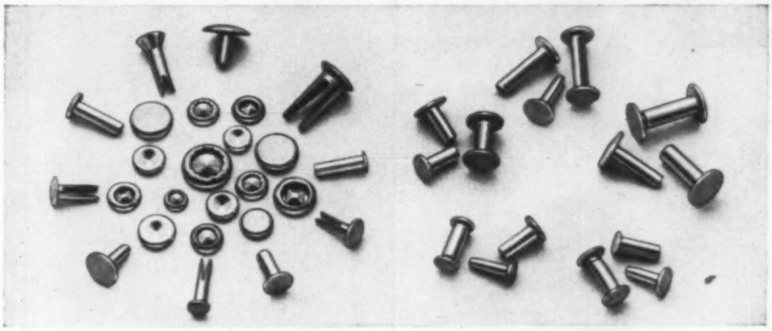


Fastener Facts

by Henry Peterson, Chief Engineer — Judson L. Thomson Mfg. Co.

DESIGN
PRODUCTION
& PURCHASING
DATA

HOW TO MAKE BOTH ENDS NEAT



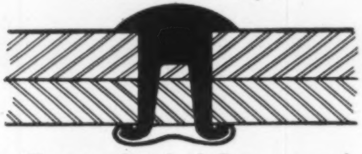
Is This Your Problem?

When both ends of a fastener can be seen and touched, it's often a problem to design an assembly that has neat lines and smooth surfaces.

Two Solutions:

The rivets pictured above show two popular means of making both ends neat. The most common way is to clinch the rivet inside a cap that looks like the head. The greater bearing surface provided by the caps prevents rivets from tearing loose and also strengthens materials. The other method is to use compression rivets, consisting of accurately matched pairs of solid and deep-drilled rivets that give a secure pressed fit.

1. Rivets Plus Caps



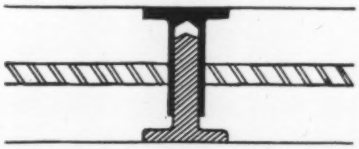
Thomson Standard Caps are made of steel and brass in diameters ranging from ¼" to 9/16" with flat or concave backs. They can be finished or japan-colored to match the self-piercing Thomson Deep-Drilled or Bifurcated (Split) Rivets of your choice.

Clinch strength with caps depends on your choice of rivet. The scored clinch of deep-drilled rivets is much stronger than the two-legged clinch of split rivets of the same diameter.

Thomson Caps are applied by a two-hopper machine that automatically feeds and sets all standard sizes of Thomson Deep-Drilled and Split Rivets and their matching caps. Hand-fed machines are also available.

Thomson Machines, in both bench and floor models, can be had to meet your special requirements.

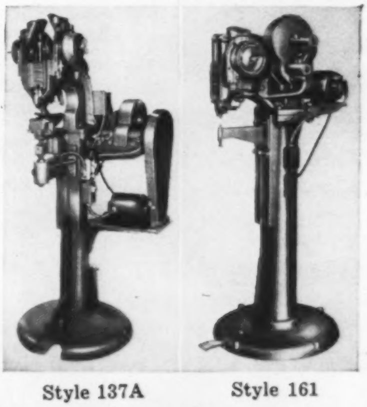
2. Compression Rivets



Thomson Compression Rivets come in precision-made male and female pairs. Each pair consists of a solid rivet with chamfered shank and a deep-drilled rivet to match. Because their most common use is for attaching handles to knives, they are often called "Cutlery Rivets".

Thomson Compression Rivets — cold headed from aluminum, brass, nickel silver and steel — are designed to seat snugly in counterbored holes. So, they give a smooth, projectionless surface to the product or assembly. They also provide the strongest pressed fit in the rivet industry. Heads may be trimmed in a secondary operation when more critical tolerances are required.

You have a choice of Thomson Rivet-Setting Machines for applying Compression Rivets: Thomson Knife Handle Machine (Style 137A) or two standard Thomson Rivet-Setting Machines (Style 161) in tandem.



Style 137A Style 161

The Thomson Knife Handle Machine is a versatile special-purpose machine that inserts male and female rivets into assemblies in a single operation. It handles rivets with heads up to 3/16" diameter . . . and lengths up to 1". Its arm is adjustable for the various assembly thicknesses and rivets lengths within its capacity.

When two standard Thomson Rivet-Setting Machines are used, one inserts the deep-drilled rivet; the other sets the solid rivet into the mate's hollow shank.

Complete Line:

Whatever your fastening problem, there's a Thomson Rivet that will cut costs and speed assembly. More than 800 stocked standards and more than 8000 standards in print-form promise you the kind of service that saves time and money.

More than 250 styles of Thomson Rivet-Setting Machines also offer you the advantages of high production rates on your assembly lines. The machine of your choice is custom-tooled for your application and factory-tested on actual samples before shipment. Available on a purchase or lease basis.

Design and Engineering Service

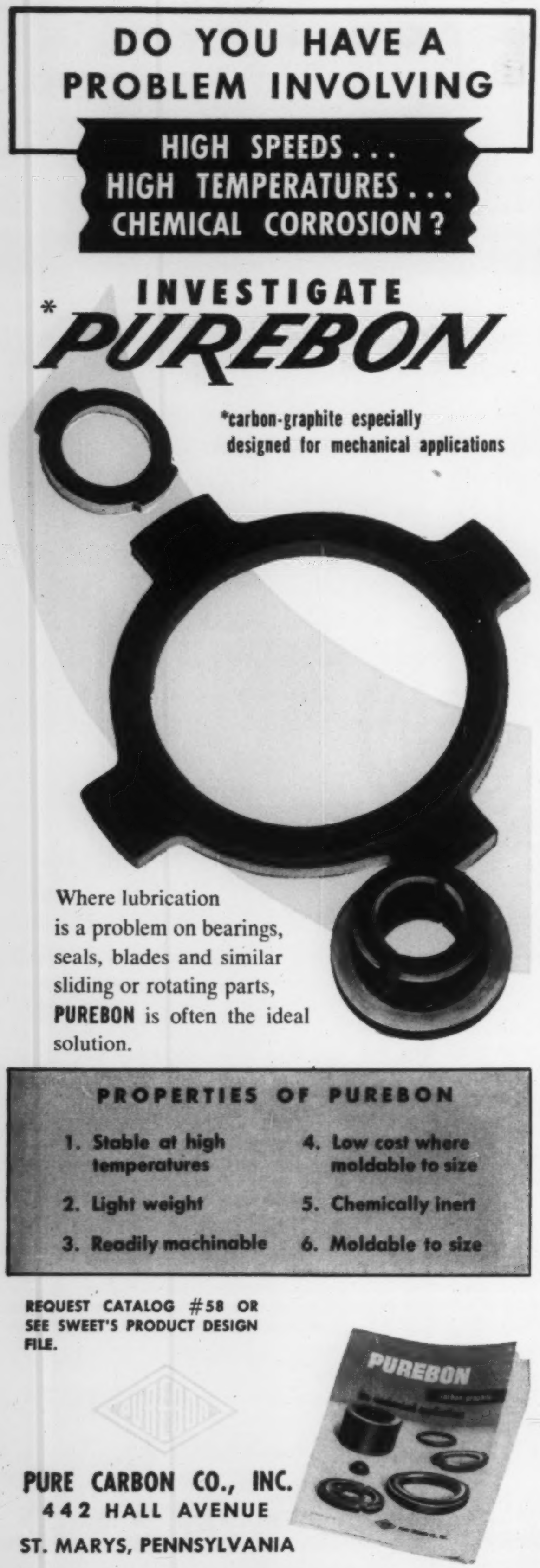
Thomson analyzes your fastening problems and makes specific rivet and machine recommendations . . . at your request. When called in before designs are frozen, our engineers can help you design around standard rivets and machines that cut costs and speed assembly. Thomson also saves time and money on your current fastening jobs by giving you a choice of more than 800 standard rivet types and sizes. Submit sketches, prints or samples for recommendations and quotations.

Free "Fastener Fact File"

This authoritative manual on all phases of riveting is "must" reading for anybody responsible for specifying or buying low-cost fasteners. It covers rivet types, applications, materials, finishes and other factors that simplify selection of the right rivet machine for any job. For your free copy, write: Judson L. Thomson Mfg. Co., Dept. B, Waltham 54, Mass.

Fastener Fact File

JUDSON L. THOMSON MFG. CO., WALTHAM 54, MASS.


DO YOU HAVE A PROBLEM INVOLVING

HIGH SPEEDS . . .
HIGH TEMPERATURES . . .
CHEMICAL CORROSION?

INVESTIGATE
*PUREBON

*carbon-graphite especially designed for mechanical applications

Where lubrication is a problem on bearings, seals, blades and similar sliding or rotating parts, **PUREBON** is often the ideal solution.

PROPERTIES OF PUREBON

1. Stable at high temperatures
2. Light weight
3. Readily machinable
4. Low cost where moldable to size
5. Chemically inert
6. Moldable to size

REQUEST CATALOG #58 OR SEE SWEET'S PRODUCT DESIGN FILE.

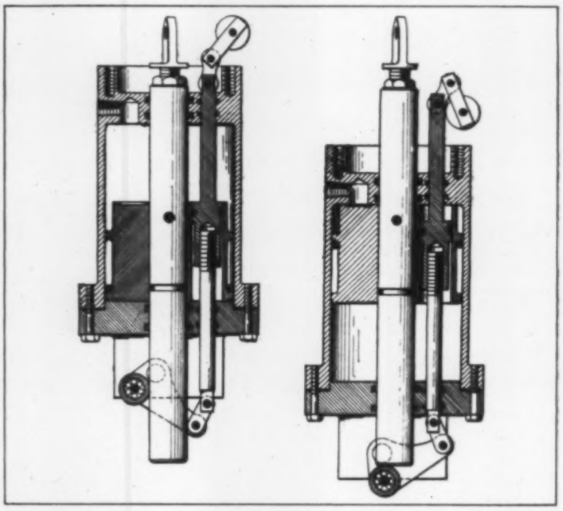
PURE CARBON CO., INC.
442 HALL AVENUE
ST. MARYS, PENNSYLVANIA

Circle 559 on Page 19

plates compress, allowing cam rings to separate axially. Driven load then freewheels until load falls to preset value. *Patent* 2,802,354 *assigned to General Motors Corp., Detroit, Mich., by Arthur F. Bohnhoff and Paul V. Wysong, Saginaw, Mich.*

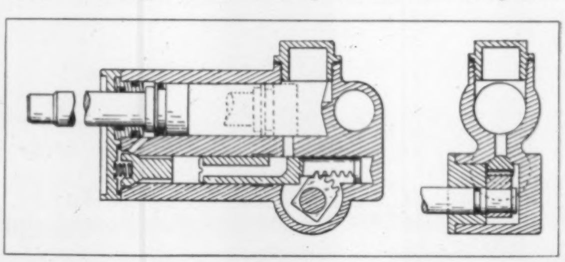
Sequenced-Motion Actuator

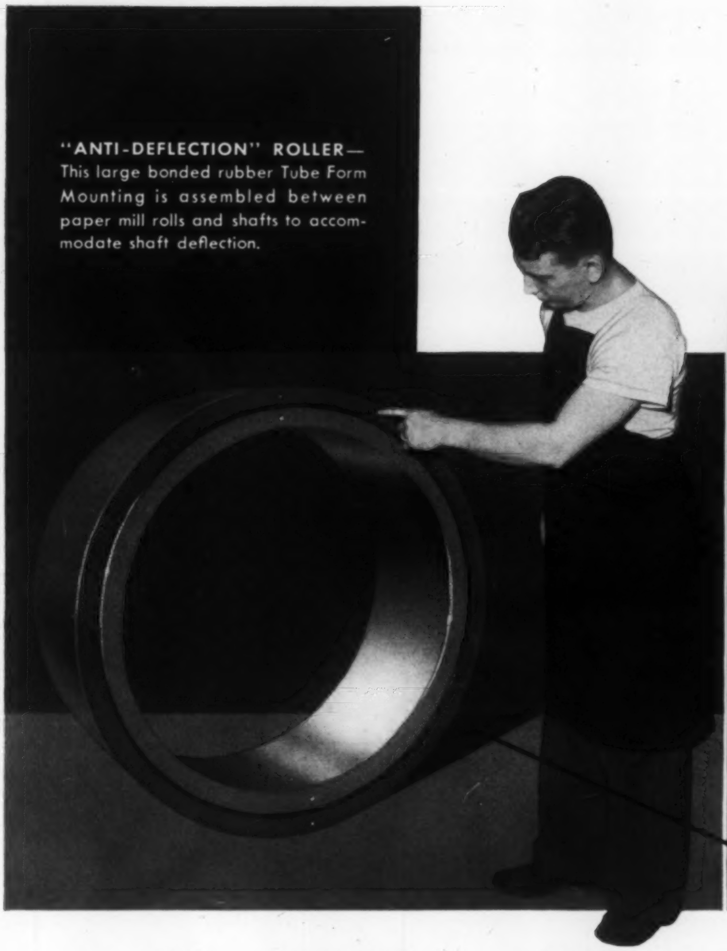
Extension and retraction of large and small pistons in a dual-piston fluid actuator are sequenced mechanically by an integral linkage. Shown here in both-pistons-retracted position (left) and both-pistons-extended position (right), the unit incorporates parallel piston and rod assemblies, with the smaller cylinder bore passing through the larger piston body. With application of fluid pressure, large-diameter piston extends first, while motion of small piston is momentarily blocked by bell-crank linkage (lower left). When large piston reaches end of extend stroke, roller on locking linkage rides free of large piston rod, permitting extension of small piston. Sequence of operation reverses during retract stroke, with small piston actuating first. Typical use is in sequenced processing operations, such as clamp and form. *Patent* 2,802,338 *assigned to McLean Development Laboratories Inc., Dallas, Tex., by Arthur R. Lardin, Amityville, N. Y.*



Fluid-Power Package

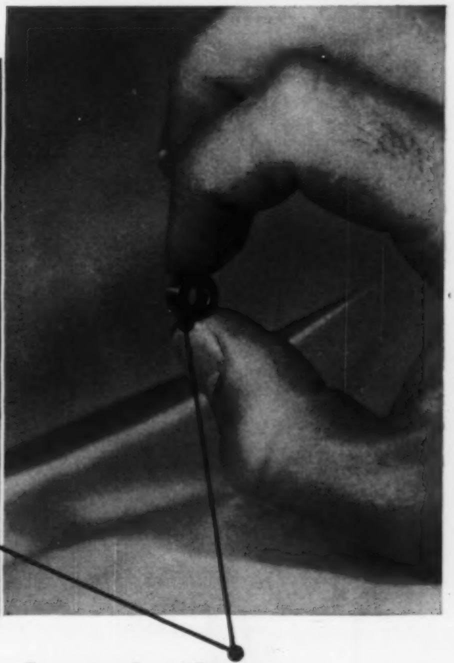
Hand-powered reciprocating pump, fluid actuator, and valving are combined in a packaged fluid-power unit. Buildup of excessive pressure in the system





"ANTI-DEFLECTION" ROLLER— This large bonded rubber Tube Form Mounting is assembled between paper mill rolls and shafts to accommodate shaft deflection.

VIBRATION ISOLATING MOUNTING— Lord skill in precision manufacture is demonstrated in the production of this Tube Form Mounting with 3/8" O.D., made to extremely close tolerance and concentricity requirements. Elastomer is bonded to dissimilar metals; brass inside, stainless steel outside.



the facilities which produced these are available to solve your vibration problems

The bonded rubber tube form mountings shown are illustrative of the wide variation in size and application of vibration and shock control products designed and manufactured by LORD. The large mounting is assembled into an "anti-deflection" roller for a paper mill; the small unit is a full bonded vibration isolating mounting.

Between these extremes, LORD has produced successful solutions to tens of thousands of problems involving operating loads from a few ounces to many tons. LORD products include many shapes, and size variations from fractions of an inch to several feet. LORD has the facilities needed to produce this great variety of parts with closely coordinated research, engineering, and precision manufacturing. All of these plus LORD's extensive know-how will be applied to the solution of your vibration and shock control problems. Contact LORD at any of the Engineering Field Offices, or the Main Office, Erie, Pennsylvania.

FIELD ENGINEERING OFFICES

ATLANTA, GEORGIA - CEdar 7-1123
BOSTON, MASS. - HAncock 6-9135
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CLEVELAND, OHIO - SHadyside 9-3175
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DETROIT, MICH. - TRinity 4-2060
KANSAS CITY, MO. - WEstport 1-0138
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"In Canada—Railway & Power Engineering Corporation Limited"

LORD MANUFACTURING COMPANY • ERIE, PA.

LORD
BONDED RUBBER

designers and producers of bonded rubber products since 1924

Circle 560 on Page 19

NOISE Bothers The Patient As Well As The Drilling

Scott Sound Level Meter Aids The S. S. White Dental Mfg. Company To Produce a Quieter Dental Instrument

The Noise of modern high-speed dental equipment can be very annoying to patients. White's engineers use the Scott 410-C Sound Level Meter in production testing of their new ball-bearing hand piece to insure that the noise of finished instruments does not exceed the standard set for them.

Completely Portable Sound Level Meter Helps YOU Design A Quieter Product

A quiet product gives you an important sales advantage. H. H. Scott's sound Level Meter, and Sound Analyzer can help you locate, measure and minimize noise and vibration. Here are important features of the Scott Sound Level Meter and Sound Analyzer.

- Sound Level Meter is flash-light size weighing only 2 lb. 7 oz. Sound analyzer is only 10" x 10" x 6".
- Extreme portability and battery power of these instruments makes them easy to set up and use in field measurements.
- Both instruments meet all applicable standards of the American Standards Association.
- Sound Analyzer has Passband adjustable in half octaves for more precise measurements.
- Sound Level Meter received the Electrical Manufacturing Award for outstanding design.

Fill out coupon! Learn how the Scott Sound Meter and Analyzer can help you

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Send me complete information on Scott Sound Level Meters and Analyzers and your FREE booklet "NOISE SIMPLIFIED."

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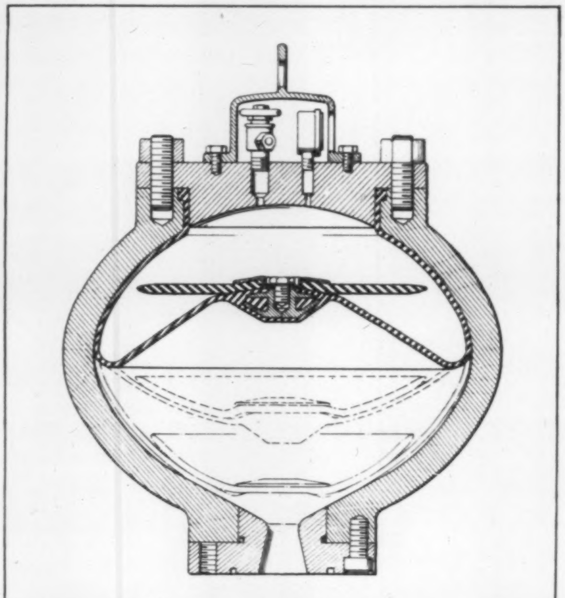
after the piston has been pumped to the fully retracted position (dashed lines) is prevented by a check-valve arrangement. Piston is released for extension by an external spring when the pump handle is rotated beyond its normal operating limit. *Patent* 2,817,210 *assigned to Airway Products Inc., Pontiac, Mich., by Ernst F. Klessig, Mackellar K. Grahm, and Ray J. Raupp.*

Self-Cleaning Pulsation Damper

Sediment buildup in a hydraulic-system pulsation damper is prevented by the self-cleaning action of its diaphragm. Mounted on the gas-pressure side of the diaphragm, a stiff rubber disc progressively conforms to and stiffens the diaphragm on the downward stroke. Result is to sweep out sediment accumulation when hydraulic pressure is released and the diaphragm bottoms. Back-up disc also minimizes diaphragm folding and wrinkling. Typical use is for smoothing pressure peaks in oil-field pumping operations. *Patent* 2,804,884 *assigned to Hydril Co. by Granville S. Knox.*



Power-Steering Booster

Centering of control-valve position in an integral-type power-steering booster is accomplished without removing the booster from the steering linkage. Design object was to facilitate installation and to allow the neutral point to be reset after long or unusually severe vehicle service without requiring the unit to be serviced on a test stand. In a typical installation, the motor-valve combination is anchored to the vehicle frame at the right-hand fitting, and the left-hand flange is connected to the vehicle tie rod. Movement of the spring-loaded valve is effected by the Pitman-arm connection. *Patent* 2,803,223 *assigned to Vickers*

Circle 561 on Page 19

STAR-KIMBLE *reports to industry*

One of a series of advertisements describing unusual electro-mechanical problems solved by S-K engineering and equipment. You may have a similar problem—or a completely different one. In either case, bring it to Star-Kimble.

DISASSEMBLED AND AIRBORNE IN 1 HOUR -- that was a basic design requirement for brakemotors powering portable aircraft hoists. Other essentials included extremely light weight, very high power output per unit of volume and very low level of radio interference. S-K custom engineered the design for a manufacturer of special Air Force equipment and has built many units. Power supply for the brakemotors is 28 volts d-c; hoist must be capable of lifting a load of 10,000 pounds; provision is made in the S-K design for regulating the speed of the hoist when load is being lowered.

PURE SINE WAVES FROM 2 to 2000 CPS are needed in the power supply of a massive vibration exciter with continuous rated force output of 12,500 pounds and capable of attaining accelerations up to 10 g with loads of 975 pounds. Precision measurements are based on sinusoidal table motion. Heart of the machine is the S-K rotary power unit comprising: 75 hp 60 cycle motor; 460 v. d-c generator; 230 v. field exciter; 460 v. variable speed d-c motor; and two pure sine wave alternators, one covering the range from 2-500 cps, the other 500-2000. No capacitors are needed for power factor correction over entire range.

IN AND OUT OF COLD STORAGE go the lift trucks that shuttle back and forth in refrigerated warehouses, passing from temperatures of -38° to normal ambients. Starting with its standard design for electric truck motors, S-K developed a special varnish treatment for the Class B insulation to enable it to withstand the severe moisture condensation encountered. This varnish treatment is used on both drive and pump motors, which have been in daily service for periods as long as five years under severe loading conditions; motors have required little or no maintenance.

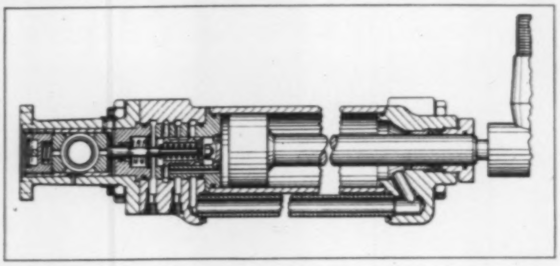
Circle 562 on Page 19

STAR-KIMBLE INDUSTRIAL MOTOR DIVISION

SAFETY INDUSTRIES, INC.

P. O. BOX 904 NEW HAVEN, CONN.

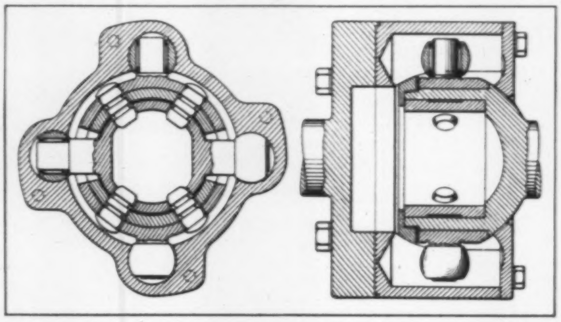
MOTORS • GENERATORS • DISK BRAKES • SPECIAL ROTATING AND CONTROL PACKAGES



Inc., Detroit, by James E. Phelan, Matt Marich, and Ernest J. Larson, Globe, Ariz.

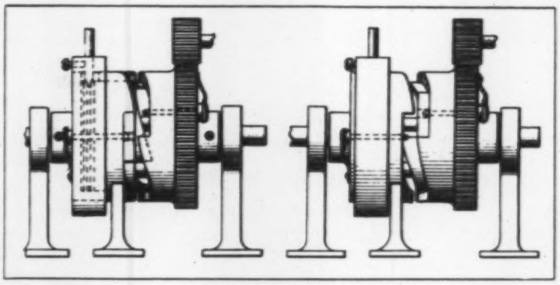
Four-Trunnion Universal Joint

Capacity of a four-trunnion universal joint is considerably greater than that of conventional cardan types. Increased load capacity and longer service life results from differential trunnion mounting system which permits relative motion between trunnion pairs. Result is to maintain all trunnions in active operation, even under 20-deg maximum shaft misalignment. *Patent* 2,802,352 *assigned to Borg-Warner Corp., Chicago, Ill., by Edmund B. Anderson, Rockford, Ill.*



Positive-Acting Clutch

Both positive engagement and positive stop are provided by a jaw-type clutch that can be actuated when clutch parts are in relative motion. Principal components are rotatable driving and driven members and a stationary member. Axial movement of the driven member brings its jaws into either positive-drive engagement with the driving member (right-hand view), or positive-stop engagement with the stationary member (left-hand view). Clutch is intended for application where a load must be driven intermittently at high speed. *Patent* 2,803,323 *assigned to General Electric Co. by John R. Newell.*



"SHEAR-SEAL" 4-WAY VALVES, 0 TO 250 P.S.I. AIR

$18.50
List Price*

*$18.50 is the list price for the 1/4" port size and $19.50 for the 3/8" less usual quantity discounts.

NO MORE
AIR VALVE
TROUBLES
FROM DIRT OR CORROSION
(AND WITHOUT COSTLY FILTERS AND OILERS)

Important Savings	Low initial cost. Need no oilers and filters (time and materials savings).	All components are corrosion resistant.
Low Maintenance	Sealing qualities do not diminish with long, continued use.	Wear compensating "Shear-Seal" design.
Long Service Life	No production delays. Maintenance (rarely needed), without disturbing plumbing.	Lapped metal to metal sealing members.
Not Critical to Dirt	No scoring or binding. (As with spool or poppet designs.)	Flow is through "Shear-Seals." Sealing surfaces remain in constant intimate contact.
No Creeping Cylinders	Leakproof closure. (No internal port to port leakage.)	Maintained through lapping action of each operation.

Ask for bulletin A-5.

Foot operated models with or without spring return to reverse or to center are $24.50 list for the 1/4" and $25.50 for the 3/8" valve less quantity discounts.

BARKSDALE VALVES

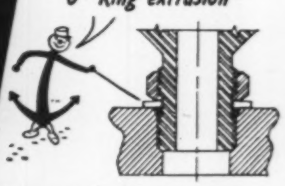
5125 Alcoa Avenue, Los Angeles 58, California

Circle 563 on Page 19

NOW
an **IMPROVED** *and*
BROADER LINE *of*
ANCHOR
SAE STRAIGHT THREAD
"O" RING BOSS FITTINGS

45° Adjustable Elbow
90° Adjustable Elbow
Tee
Service Tee

"This NEW Back Up Washer eliminates "O" Ring extrusion"



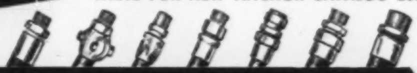
Today, Anchor is offering not only a more extensive line of SAE Straight Thread "O" Ring Boss Adapters, but one that is also greatly improved.

These fittings are now equipped with a factory installed, Back Up Washer that eliminates any possibility of "O" Ring extrusion.

An even greater selection of standard sizes is now available in Anchor's already comprehensive line.

Anchor's new Catalog No. 203, describes the broader line of SAE Straight Thread "O" Ring Fittings and the complete line of Standard Adapter Unions and Pipe Fittings. Write for it today!

WRITE FOR NEW ANCHOR CATALOG 203

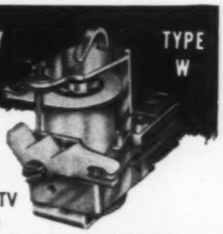


ANCHOR COUPLING CO. INC.

320 North Fourth Street, Libertyville, Illinois
Branch Offices: Dallas, Tex., Plymouth, Mich.

Circle 564 on Page 19

IMPULSE LATCHING RELAY **TYPE W**



Features an insulated rocker arm activated by a single coil, instead of the usual two. Ideal for machine controls, appliances, positioning devices, remote TV controls and other applications where opposite switching is desired each time circuit is pulsed. Contact combinations up to 4 "C"; rated 7½ amperes @ 115 V. AC resistive.

NEW RELAYS

by

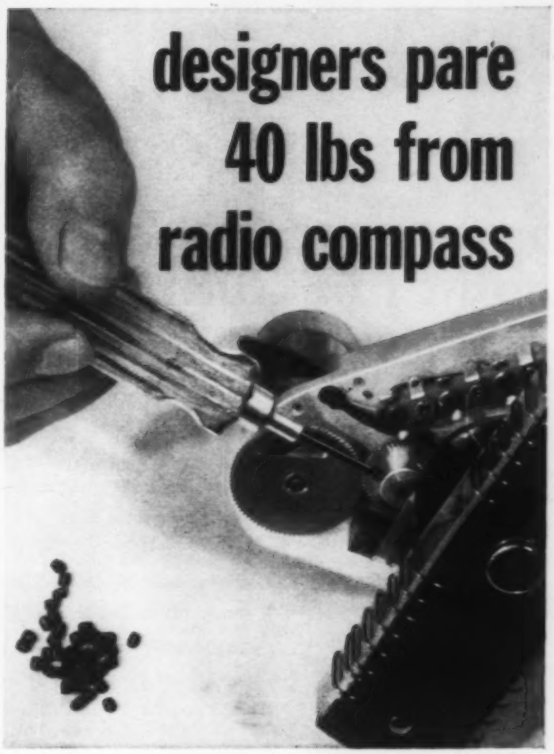
Comar ELECTRIC COMPANY
3349 ADDISON ST., CHICAGO 18, ILLINOIS

Suitable for use in a wide range of applications. For AC or DC operation. Compact size, lightweight. Shock and vibration resistant. Positive contact pressure. Contact combinations up to 3 "C". Contact rating, 5 amp. resistive with 5/32" dia. (10 amp. with 3/16" dia.). Available open, or in plastic dust covers with plug-in feature, as illustrated.
Send For Details

TYPE M **LIGHT DUTY GENERAL PURPOSE RELAY**

RELAYS • SOLENOIDS • COILS • SWITCHES • HERMETIC SEALING

Circle 565 on Page 19



... but stick to Bristol socket screws

Engineers at Aircraft Radio Corporation, Boonton, N. J., have done an outstanding job of miniaturization in their new ARC Type 21 Automatic Direction Finder—reducing bulk 60% and weight to only 19.1 lbs—as against 60-100 lbs for older models, with no sacrifice in performance.

Like many other ARC navigation and communication aids for aircraft, the new direction finder uses Bristol Multiple-Spline socket set screws in many places such as the antenna shown above during assembly. ARC engineers particularly like these Multiple-Spline features:

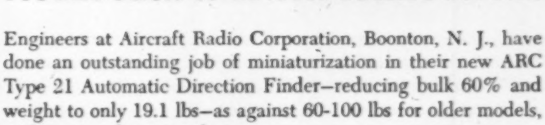
1. Production simplification—ARC experience has shown that the wrenches grip more uniformly and securely with the Multiple-Spline screws. Assembly is faster and easier.

2. Performance reliability—a vital factor in ARC's equipment. Bristol Multiple-Spline set screws hold fast under shock and vibration because they can be wrenched up tighter.

Bristol socket screws—most complete line on the market, industry standard hex, as well as Multiple-Spline sockets—are sold by leading industrial distributors. See your distributor. He can frequently give you valuable help on your particular problems and save you time on deliveries from his complete stocks.

A.8.2

Precision socket screw manufacturers since 1913


Bristol's Hex Socket Screws
Bristol's Multiple-Spline Socket Screws

*Made in sizes as small as No. 0 in Alloy Steel and Stainless Steel. Cap screws up to 1½" diam.

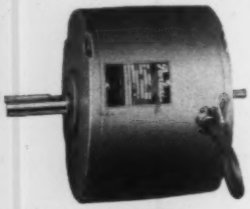
THE BRISTOL COMPANY Socket Screw Division
Waterbury 20, Conn.

Circle 566 on Page 19

ONLY **ONE** MOTOR IS RIGHT FOR YOUR APPLICATION...

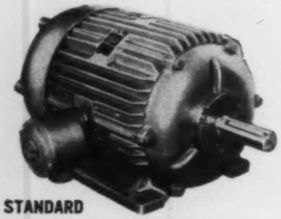
SPRAY-TIGHT

Fan cooled; 7½ HP; Navy; Hi-shock to Navy Spec. MIL-M-17060A.



TOTALLY ENCLOSED

Blower and Drive Motor; 4 HP; air drawn over motor.



STANDARD EXPLOSION-PROOF MOTOR

1 to 30 HP; also with NEMA C face and NEMA D flange.

● One thing's certain—just one motor is right for your application. Design engineers turn to Peerless more often than ever today because Peerless is equipped to produce the motors that power their machines best. There's no need to fit the machine to the motor. Peerless has hundreds of motor designs—many of them created specifically to meet OEM problems. Give your next motor problem to the Peerless Representative near you or write directly to the factory. We'll work with you to develop the one motor that meets your needs best.

SPECIAL CONSTRUCTION

Motor to fit customer's application design.

ELECTRIC MOTOR DIVISION

THE Peerless-Electric® COMPANY

FANS · BLOWERS · MOTORS

1520 W. MARKET ST. • WARREN, OHIO

Circle 567 on Page 19

design flexibility in glass

LANCASTER GLASS CORP., LANCASTER 2, OHIO

Glass bases for the Esterbrook desk sets are moulded, decorated and ground by Lancaster Glass. The production process includes the addition of fired-in ceramic color and an intricate grinding technique.

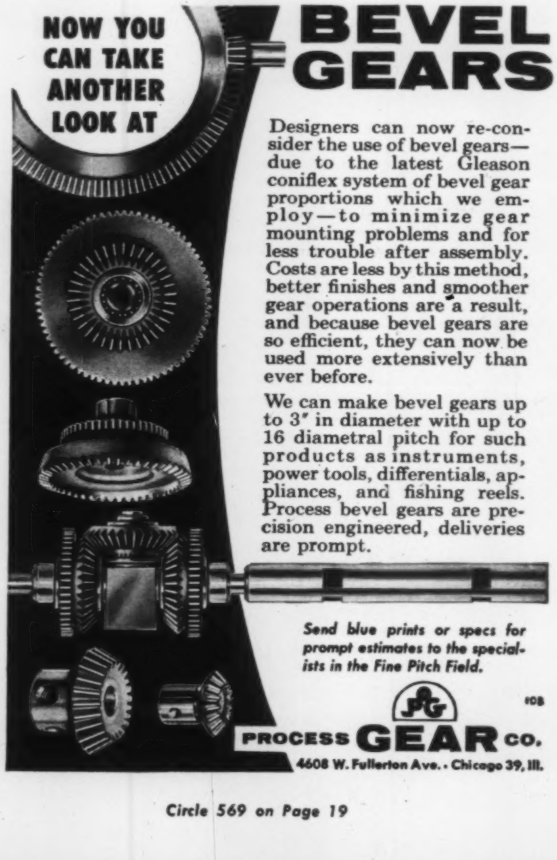
This operation is typical of Lancaster's close cooperation with customers. Companies like Esterbrook consider Lancaster design and manufacturing facilities an integral part of their production system.

Lancaster can add sales appeal to your product with design flexibility and lower cost glass parts. Write for details, or submit blueprints for immediate quotation.

Lancaster glass

to brighten your product's future

Circle 568 on Page 19



BEVEL GEARS

Designers can now re-consider the use of bevel gears—due to the latest Gleason coniflex system of bevel gear proportions which we employ—to minimize gear mounting problems and for less trouble after assembly. Costs are less by this method, better finishes and smoother gear operations are a result, and because bevel gears are so efficient, they can now be used more extensively than ever before.

We can make bevel gears up to 3" in diameter with up to 16 diametral pitch for such products as instruments, power tools, differentials, appliances, and fishing reels. Process bevel gears are precision engineered, deliveries are prompt.

Send blue prints or specs for prompt estimates to the specialists in the Fine Pitch Field.

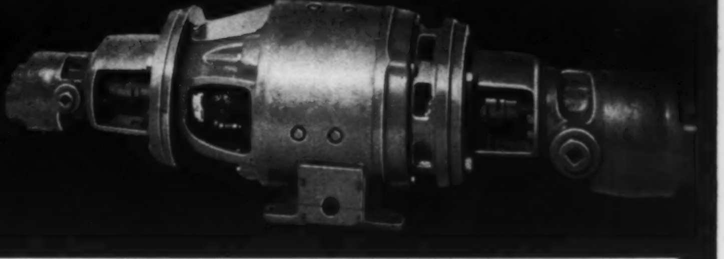
#08

PROCESS GEAR CO.

4608 W. Fullerton Ave. · Chicago 39, Ill.

Circle 569 on Page 19

How stock pumps solve special problems



CASE HISTORY NO. F3954.

The photograph above illustrates Brown & Sharpe's solution of a turbine manufacturer's design problem. The heat absorbed by the turbine during normal operation makes necessary a cooling-off period of about 72 hours prior to inspection or repair of the rotor. To prevent bearing seizure and excessive shaft deflection during this period, the rotor must be turned slowly and the bearings cooled. Brown & Sharpe designed one economical, compact unit to do both jobs: two stock pumps were combined with a special motor to drive them both, one turning the rotor at 1 revolution per hour and the other providing cooling oil to the bearings.

Brown & Sharpe's complete line of gear, vane and centrifugal pumps — backed up by an engineering staff with the experience and knowledge to provide expert advice — has enabled our customers to realize substantial savings in thousands of applications.

For information about B&S pumps for fluid transfer please write to Brown & Sharpe Mfg. Co., Providence, R. I.

For information about pumps and valves for hydraulic applications, write to Double A Products Company, a subsidiary of Brown & Sharpe, Manchester, Mich.

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Circle 570 on Page 19

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ELECTRO-FLEX

solves another difficult heating problem.

THIS TIME FOR...

Western Gear Corporation
Lynwood, California

Performance: −65°F. ambient to 450°F. heater temp.
Material: Silicone, vulcanized into precision metal clamp.
Rating: 400 W, 1150 V, 40 w/sq. in.

This quantity production heating element for W.G.C. heats the nut of a ball screw actuating rod on an airplane landing gear assembly. To melt out ice, it is energized just before landing gear is raised or lowered. It embodies a molded-in thermostat which holds temp. to approx. 250°F.

If you have a special heating problem let us solve it for you. We are specialists in light-weight, tough, flexible elements of any shape or size. Units may be designed to operate under high pneumatic pressure. Insulation may be Silicone Rubber or Neoprene. Elements may be immersable or resistant to corrosion. All units meet USAF specifications.

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"FIRST with STANDARD ELEMENTS"

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MF

PROJECTION WELD NUTS

SOLVE PRODUCTION DELAYS CUT MANUFACTURING COSTS

fuse nut to the product in exact location

Pilot type
Provides quick, accurate positioning. Pilot forms barrier preventing weld spatter in threads.

Recessed type
Recess avoids clogging of threads by weld flow or spatter — no retapping.

Engineered for assembly simplification. The welding of nuts to subassemblies permits the use of screws or bolts in the main assembly without the need for holding nuts from turning, cutting time and labor.

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Final assembly is faster, easier. Speed and simplify production—improve design—cut costs.

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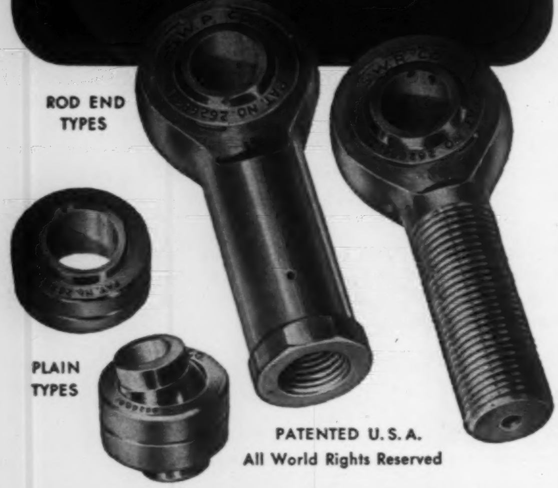

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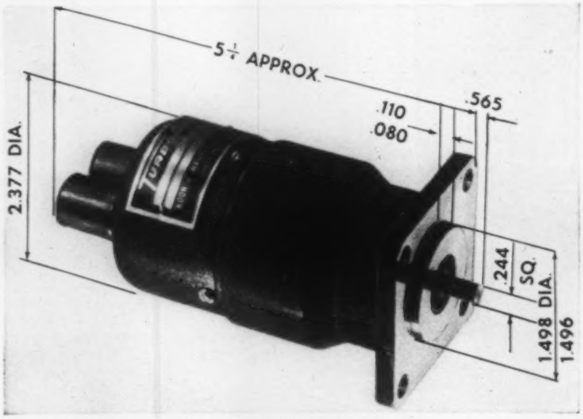

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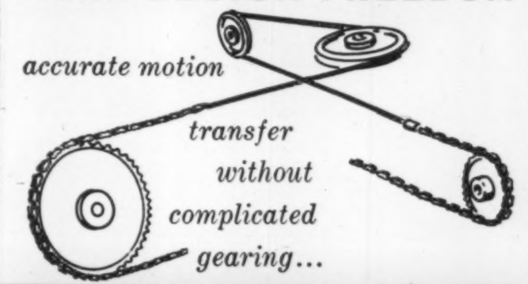

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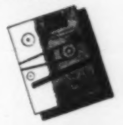

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Model LD 1.
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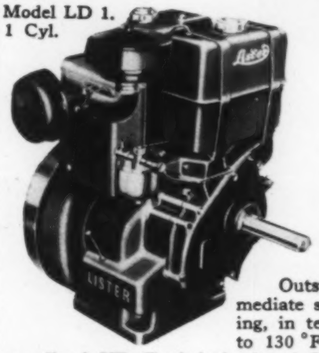

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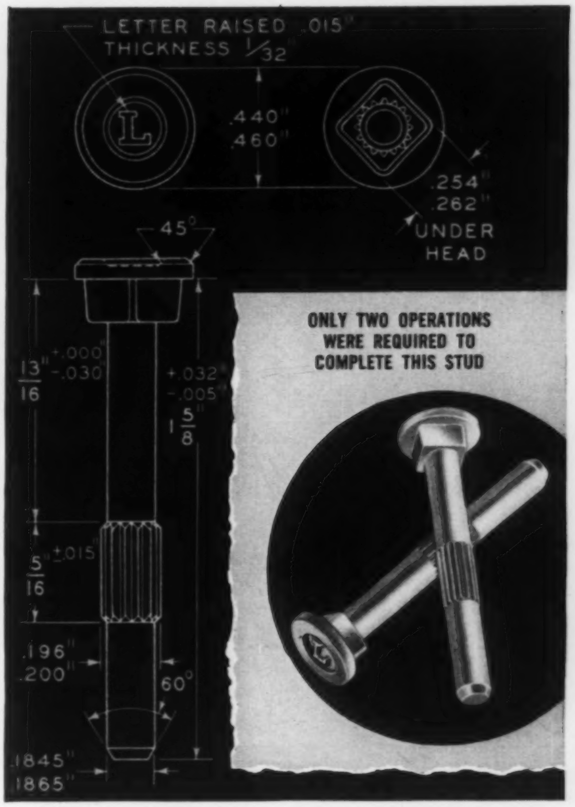

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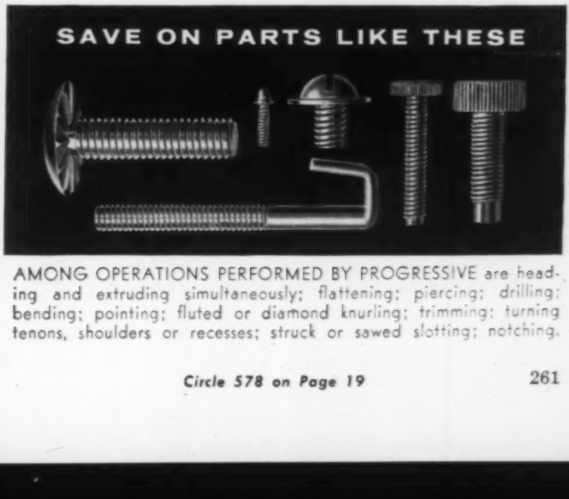
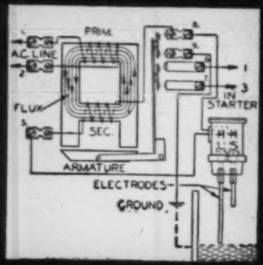


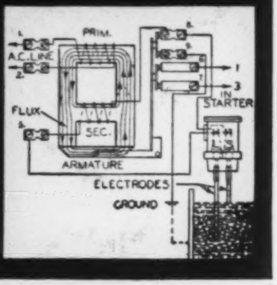
AMONG OPERATIONS PERFORMED BY PROGRESSIVE are heading and extruding simultaneously; flattening; piercing; drilling; bending; pointing; fluted or diamond knurling; trimming; turning tenons, shoulders or recesses; struck or sawed slotting; notching.

Circle 578 on Page 19

LIQUID LEVEL CONTROL
with the
B/W RELAY



Type LH Relay
for
Pump Down Control



POSITIVE AND DEPENDABLE

The B/W system of liquid level control consists of a transformer type induction relay and a holder for one or two electrodes, depending on the desired operation and the type of relay used. The relay incorporates a primary or line voltage coil connected to a permanent source of alternating current, and a secondary or electrode circuit coil connected to the electrodes immersed in the liquid being controlled. Energizing the primary coil causes an induced voltage in the secondary coil; thus the secondary coil is never connected to the power line.

LIQUID IS ELECTRICAL CONDUCTOR

The liquid itself is the electrical conductor that completes the secondary circuit. When this secondary circuit is completed, by the liquid contacting both electrodes, the magnetic attraction set up in the legs of the relay core causes the armature to close, and open or close the load contacts. A built-in holding circuit maintains this contact until a predetermined fall in liquid level breaks the circuit. By adjusting the electrode settings, the range of operation can be controlled.

FOR PUMP UP and PUMP DOWN APPLICATIONS, SIGNALS and ALARMS

B/W relays are designed for either pump up or pump down operation. In addition, by using a single electrode they are well suited for signal and alarm applications.

NO MOVING PARTS

The complete absence of moving parts in the liquid insures long and trouble-free performance. Because of the very low current in the secondary circuit these relays are ideal for many switching jobs outside of the liquid level field.
Consult our engineering department on any special control applications.

CATALOG
on request

- It covers the complete line of B/W Induction Relays, Enclosures, Contactors and Starters, Multiple Pump Controls, Electrode Holders, Starter and Relay Combinations, Special Controls and Panels.

B/W CONTROLLER CORPORATION
2180 E. Maple Road, Birmingham, Mich.

FIRST IN THE FLOATLESS CONTROL FIELD

Circle 579 on Page 19

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grooved fasteners
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Do You Have This Catalog?

Contains Complete details on grooved pins and studs
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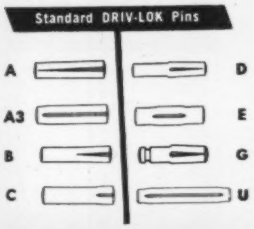
Write for your copy of the DRIV-LOK catalog today. Contains factual data in concise, easy to use form. Illustrated with typical applications that may help solve a fastening problem for you. Sent without obligation, of course.



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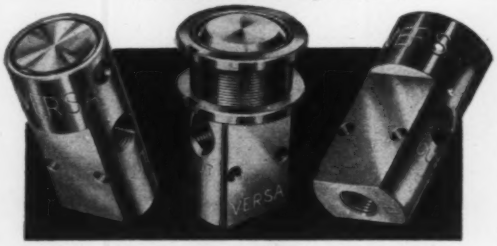
715 Park Avenue • Sycamore, Illinois

Circle 580 on Page 19

Versa "A" Valves
Give MAXIMUM Capacity
In MINIMUM Space...



- Versa solves the space problem with a truly economic valve.
- The overall size of the Versa "A" valve is only 2" high by 1" in diameter, yet it has the capacity of much larger valves.
- Ideal for controlling cylinders, instruments and larger pilot valves.
- Available in ⅛" NPT in 2-way & 3-way types with or without button guard, in either normally open or closed models.
- Simple to mount on equipment or can be furnished for panel mounting.
- Prices range from $4.00 to $6.50 each.
For complete information write today for Folder #14S.

VERSA
VERSA PRODUCTS COMPANY INC.
247 SCHOLES STREET, BROOKLYN 6, N.Y.

FREE CATALOG!
Write today for your free copy of Versa's Catalog #14.

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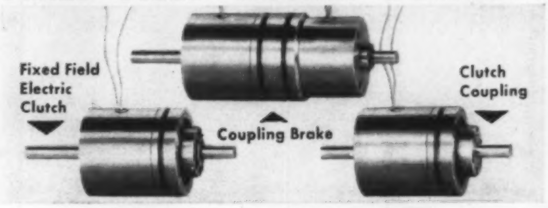
Introducing . . .

Simplatrol

FIXED FIELD Electric Clutches



In Miniature and Small Sizes

Super compact for use in instruments or assemblies where space is at a premium and performance requirements are high.

Three styles of Simplatrol Fixed Field Clutches ranging from 7/8" to 3 1/8" diameter. Torque output ranges from 10 oz. inches to 100 lb. inches.

Simplatrol Diaphragm Makes The Difference!

The only functional moving part in actuation of Simplatrol Fixed Field Clutches.

When current is applied to magnet, the diaphragm yields as the armature is attracted to the rotor body. Engagement is extremely rapid, smooth and silent.

The Simplatrol principle has been proved by years of use and features a minimum of parts to maintain or replace.

Ask for literature and recommendations on Simplatrol Fixed Field Miniature and Small Electric Clutches and Brakes.

Simplatrol products corp.
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Representation in Key Industrial Areas

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Circle 582 on Page 19

when you want precision... get

Abart CUSTOM-CUT **Gears**

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Send B/P and specs or sample for quotation. 96 pitch to 5/7 D. P.—¼" P. D. to 18" P. D.

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ABART GEAR and MACHINE CO.
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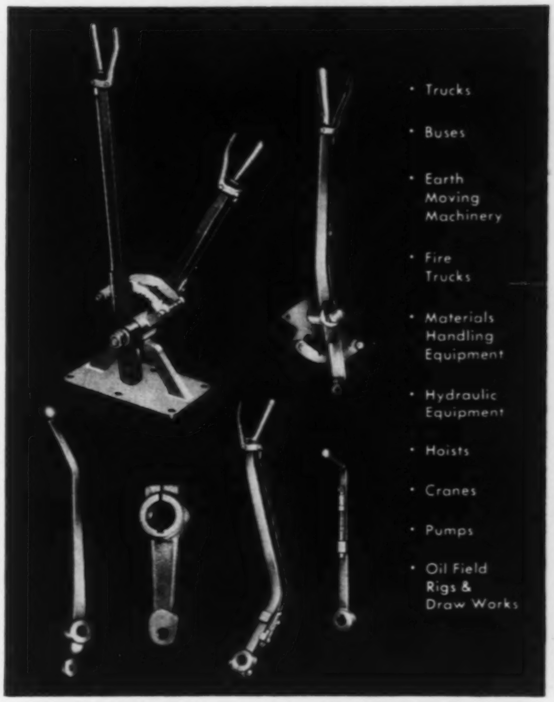
BATAVIA LEVERS

for machines and vehicles



standard, stocked forgings quickly assembled to order

NO SPECIAL ENGINEERING: Chances are there's a Batavia lever design that's either ready-made for your requirements or can be easily modified to fit the need.

NO SPECIAL FABRICATION: To meet an almost limitless number of design requirements without special dies and tooling, Batavia has developed *and stocks* an extensive line of standard upper and lower half assembly forgings, hubs, sub-levers and extensions. With all parts interchangeable, any upper half assembly forging may be joined with any lower half assembly forging or any sub-lever forging to produce the lever desired.

CONTROL UNITS, TOO: In addition to its full line of levers and lever assemblies, Batavia Metal Products also manufactures winch and transmission controls.

GET FULL DETAILS by mailing the coupon below.

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Batavia 2, New York

Mail your illustrated Lever Bulletin to us, without obligation.

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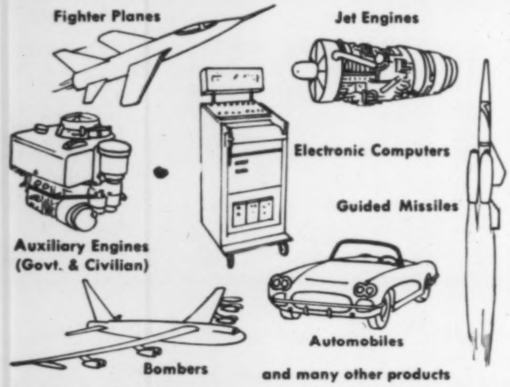
TAP-LOK®

the best, simplest, lowest-cost threaded fastener insert

—*bar none!*

TAP-LOK Quality is Proven by Current Use in



Tap-Lok Inserts provide heavy-duty steel threads for threaded fasteners in light metals, plastics and many other materials. They excel in saving time and cost in assembly, among all types of bushings designed for this purpose.

Tap-Lok Inserts are **SELF-TAPPING** and friction-locking in a single step. They increase thread strength 50% or more. They require no separate tapping operation, special hole preparation or secondary staking.

Tap-Lok Inserts are made in two types—the Regular Series, with a 2B internal thread for general applications in aluminum, magnesium and zinc die castings and sand castings; and the "H" Series, with 2B or 3B internal thread for use in wrought and high strength aluminum and magnesium castings, as in aircraft applications.

In accordance with MS 35914.

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GROOV-PIN CORPORATION

1130 Hendricks Causeway, Ridgefield, New Jersey
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Also manufacturers of Groov-Pins for positive locking press fit.

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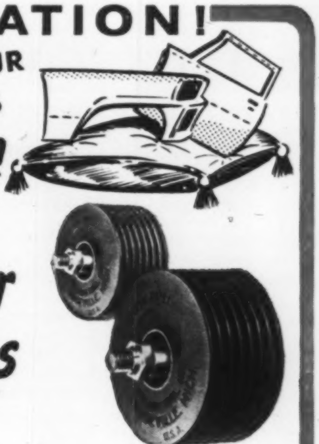
Circle 586 on Page 19

AUTOMATION!

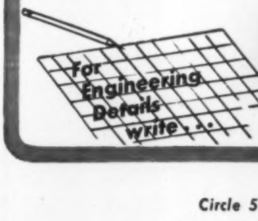
DESIGN YOUR CONVEYORS TO *Cushion* PARTS ON STILSON *Rubber Rollers*



Stilson Rubber Rollers provide the perfect cushioned, scratch free ride for all types of production parts.

Used on gravity conveyors, die lifters, or idler rolls under conveyor belts, Stilson Rollers assure positive surface protection during transportation and safety for glass or other fragile products.

Stilson Rollers are available in 2½ and 4 inch diameters and in a variety of models. They operate on a dual ball bearing axle and all parts are interchangeable.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STILSON TOOL INC.
30229 Groesbeck Hwy.
Roseville, Mich.

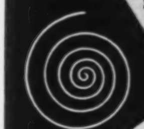
Circle 587 on Page 19

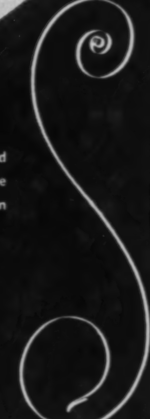
SANDSTEEL SPRINGS

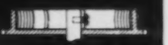
GREATER POWER MORE CONSTANT POWER

For Many Applications

If you are looking for a power spring for any of dozens of applications, look to Sandsteel for your needs. Whether your application calls for the common spiral spring or the unique SANDSTEEL crosscurved spring for either stronger or more constant power, Sandsteel can solve your spring needs. In its more than 30 years' history, Sandsteel has developed many tools and dies that are adaptable to various types of power spring manufacturing. The presence of this equipment cuts down the tooling costs to the customer when Sandsteel handles the job. When spring performance is important, specify Sandsteel.




Crosscurved spring in free condition



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Sandsteel Spring Division
Fair Lawn, New Jersey
SWarthmore 7-6200
In New York: ALgonquin 5-2200

SS-144

Circle 588 on Page 19

FREE SELECTION CHART for AGASTAT® time delay relays

AGASTAT
SELECTION CHART

Now you can select exactly the right Agastat time delay relay for your particular timing need—in a hurry. This free selection chart lists data on every popular model in the Agastat line—the most complete line of pneumatic time delay relays in the industry. They're adjustable for timing from 0.1 second to 10 or more minutes, unaffected by voltage variation, dustproof, light, and mountable in any position. And there's an Agastat model to precisely fit your requirements, including two-step, electrical interlock and double head units. A glance at the free selection chart tells you which model to order.

Write for your free copy to Dept. A26-228

AGA DIVISION

Elastic Stop Nut Corporation of America

1027 Newark Avenue, Elizabeth, New Jersey
Pioneers in pneumatic timing.

Circle 589 on Page 19

NEW! materials handling duct with highest abrasion resistance

FABRIC →
METAL →
*

Wiremold's new flexible duct, type 8K-1D, features abrasion-resistance and dust-tight construction, designed especially for handling dry, free-flowing materials and for heavy-duty exhaust work. Comparative tests show it to be at least 50% higher in abrasion resistance than other types. For full information, send for Folder No. 591 and Data Sheet S-12.

**** Exclusive construction: The positive mechanical lock unites metal and fabric securely—guarantees long life.***

other Wiremold flexible ducts for
• air • dust • fumes

WIREMOLD® *FLEXIBLE AIR DUCT*

THE WIREMOLD COMPANY, HARTFORD 10, CONNECTICUT

Circle 590 on Page 19

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Circle 591 on Page 19

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Advertising Index

Abart Gear and Machine Co. 263
A'G'A Division, Elastic Stop Nut Corporation of America 266
Airborne Accessories Corporation 220
Air Reduction Sales Co., A Division of Air Reduction Co., Inc. 74, 75
Alemite Division, Stewart-Warner Corporation 79
Allen-Bradley Co. 112
Allen Manufacturing Co. 52
Aluminum Company of America 85
American Blower, Division of American-Standard 118
American Brake Shoe Co., American Manganese Steel Division 78
American Brake Shoe Co., National Bearing Division 119
American Crucible Products Co., The 204
American Manganese Steel Division, American Brake Shoe Co. 78
American Society of Tool Engineers 199
American-Standard, American Blower Division 118
Ampco Metal, Inc. 201
AMP, Inc. 196
Anchor Coupling Co., Inc. 257
Anker-Holth Division 110
Arrow-Hart & Hegeman Electric Co., The 246, 247
Automatic Switch Co. 107

Babcock & Wilcox Co., The, Tubular Products Division 5
Barksdale Valves 256
Batavia Metal Products Corporation 263
Behlen Manufacturing Co. 35
Bethlehem Steel Co. 193
Bodine Electric Co. 1
Brainard Steel Division, Sharon Steel Corporation 101
Bristol Co., The 257
Brown & Sharpe Manufacturing Co. 259
B/W Controller Corporation 262

Cambridge Wire Cloth Co., The 218
Camloc Fastener Corporation 241
Carpenter Steel Co., The, Alloy Tube Division 269
Carter Controls, Inc. 39
Cartriseal Corporation 212
Century Electric Co. 207
Chicago Rawhide Manufacturing Co. 2
Christensen Machine Co., The, Miehle-Dexter Supercharger Division 86
Chrysler Corporation, Industrial Engine Division 116
Clearprint Paper Co. 91
Colorado Fuel & Iron Corporation, The 64, 65
Columbia Steel & Shafting Co., Summerill Tubing Division 211
Comar Electric Co. 257
Cone-Drive Gears Division, Michigan Tool Co. 185
Continental-Diamond Fibre, A Subsidiary of The Budd Co. 187
Copperweld Steel Co., Steel Division 11
Cramer Controls Corporation 189
Cutler-Hammer, Inc. 7

Damascus Tube Co. 213
Dayton Rubber Co., The, Industrial O.E.M. Division 88, 89
Denison, R. B., Manufacturing Co. 212
Diamond Chain Co., Inc. 41
Dodge Manufacturing Corporation 60
Double A Products Co., A Subsidiary of Brown & Sharpe 259
Driv-Lok Sales Corporation 262
du Pont, E. I., de Nemours & Co., Inc. .. 87, 111
Durez Plastics Division, Hooker Electronical Co. 205
Dynamatic Division, Eaton Manufacturing Co. 108, 109

Eastman Manufacturing Co. 81
Eaton Manufacturing Co., Dynamatic Division 108, 109
Eaton Manufacturing Co., Reliance Division .. 37
Elastic Stop Nut Corporation of America 113
Elastic Stop Nut Corporation of America, A'G'A Division 266
Electric Steel Foundry Co. 48, 49
Electro Devices, Inc., Servospeed Division .. 210
Electro-Flex Heat, Inc. 259

Felters Co., The 233
Firestone Tire and Rubber Co., The, World Bestos Division 231
Franklin Electric Co., Inc. 77

Gamble Brothers, Inc. 44
Gardner-Denver Co. 80
Garlock Packing Co., The 42, 43
Gast Manufacturing Corporation 239
Gates Rubber Co., The 96
Gear Grinding Machine Co., The 270
General Motors Corporation, Saginaw Steering Gear Division 63
Gleason Works 9
Goodrich Chemical, B. F., Co., A Division of The B. F. Goodrich Co. 245
Gries Reproducer Corporation 236
Groov-Pin Corporation 264

Haloid Co., The 104
Hansen Manufacturing Co., The 198
Hilliard Corporation, The 224
Hitchiner Manufacturing Co., Inc. 244
Hooker Electrochemical Co., Durez Plastics Division 205
Houdaille Industries, Inc., Wales-Strippit Division 28
Howard Industries, Inc. 125
Hubbell, Harvey, Inc. 228

Industrial Tectonics, Inc. 40
Ingersoll-Rand 219
International Nickel Co., Inc., The 191
International Packings Corporation 117

Jenkins Bros. 195
Johns-Manville 217
Jones & Laughlin Steel Corporation 229

Kaydon Engineering Corporation, The 21
Kohler Co. 94
Koontz Wagner Electric Co., Inc., Manufacturing Division 260
Kuhlmann Straube Co., Ltd. 266

Laclede Steel Co. 235
Lancaster Glass Corporation 258
Lewellen Manufacturing Co. 15
Link-Belt Co. 25, 105
Lister-Blackstone, Inc. 261
Lord Manufacturing Co. 253
Lovejoy Flexible Coupling Co. 238

McGill Manufacturing Co., Inc. 249

Mac Lean-Fogg Lock Nut Co. 259
Madison-Kipp Corporation 122
Magnetic Amplifiers, Inc. 223
Mallory-Sharon Metals Corporation 237
Manhattan Rubber Division, Raybestos-Manhattan, Inc. 102, 103
Master Electric Co., The, Division of Reliance Electric and Engineering Co. Inside Back Cover

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Advertising Index

MB Manufacturing Co., A Division of Textron, Inc. 190
Metals & Controls Corporation, Spencer Thermostat Division 120
Michigan Tool Co., Cone-Drive Gears Division 185
Midland-Ross Corporation 206
Miehle-Dexter Supercharger Division of The Christensen Machine Co. 86
Minnesota Mining and Manufacturing Co., Adhesives, Coatings and Sealers Division 208, 209
Morse Chain Co. 92, 93
Muskegon Piston Ring Co., Rotary Seal Division 16

National Bearing Division, American Brake Shoe Co. 119
National Lock Washer Co., The 69
National Supply Co., The, Industrial Products Division 242
National Vulcanized Fibre Co. 225
Norgren, C. A., Co. 62
Norma-Hoffmann Bearings Corporation Inside Front Cover
Numatics, Inc. 214

Ohio Carbon Co., The 260
Ohio Gear Co., The 243
Ohio Knife Co., The 95
Ohmite Manufacturing Co. 51

Packing Division, Raybestos-Manhattan, Inc. 102, 103
Peerless Electric Co., The, Electric Motor Division 258
Philadelphia Gear Works, Inc. 50
Plastic Products Division, Raybestos-Manhattan, Inc. 102, 103
Polymer Corporation of Pennsylvania, The 230
Potter & Brumfield, Inc. 46, 47
Process Gear Co. 258
Progressive Manufacturing Co., The, Division of The Torrington Co. 261
Protective Closures Co., Inc., Caplugs Division 121
Pure Carbon Co., Inc. 252
Purolator Products, Inc. 100

Racine Hydraulics & Machinery, Inc. 90
Raybestos-Manhattan, Inc. 102, 103
Recordak Corporation 115
Reeves Pulley Co., Division of Reliance Electric and Engineering Co. 45
Reliance Division, Eaton Manufacturing Co. 37
Reliance Electric and Engineering Co., The Master Electric Co. Division Inside Back Cover
Reliance Electric and Engineering Co., Reeves Pulley Co. Division 45
Reuland Electric Co. 97
Rivett, Inc. 240
Robbins & Myers, Inc. 82, 83
Rollway Bearings Co. 124
Rotary Seal Division, Muskegon Piston Ring Co. 16
Russell, Burdsall & Ward Bolt and Nut Co. 197

Safety Industries, Inc., Star-Kimble Industrial Motor Division 255
Saginaw Steering Gear Division, General Motors Corporation 63
Sanders Associates, Inc. 70
Sandsteel Spring Division, Sandvik Steel, Inc. 265
Sandvik Steel, Inc., Sandsteel Spring Division 265
Scott, H. H., Inc. 254
Sealol Corporation 192
Servo Corporation of America 265
Servospeed Division of Electro Devices, Inc. 210
Sharon Steel Corporation, Brainard Steel Division 101
Sheppard, R. H., Co., Inc. 204
Sierra Engineering Co. 261
Simmons Fastener Corporation 76
Simplatrol Products Corporation 263
Snap-Tite, Inc. 59
SKF Industries Inc. 68
South Chester Corporation, Southco Division 234
Southco Division, South Chester Corporation 234
Southwest Products Co. 260
Spencer Thermostat Division, Metals & Controls Corporation 120
Sperry Rand Corporation, Vickers Electric Products Division 114
Sperry Rand Corporation, Vickers, Inc. Division 61
Square D Co. 123
Staedtler, J. S., Inc. 215
Standard Pressed Steel Co. 84
Star-Kimble Industrial Motor Division, Safety Industries, Inc. 255
Statham Instruments, Inc. 220
Stearns Electric Corporation 200
Stewart, F. W., Corporation 38
Stewart-Warner Corporation, Alemite Division 79
Stilson Tool, Inc. 265
Struthers-Dunn, Inc. 194
Summerill Tubing Division, Columbia Steel & Shafting Co. 211

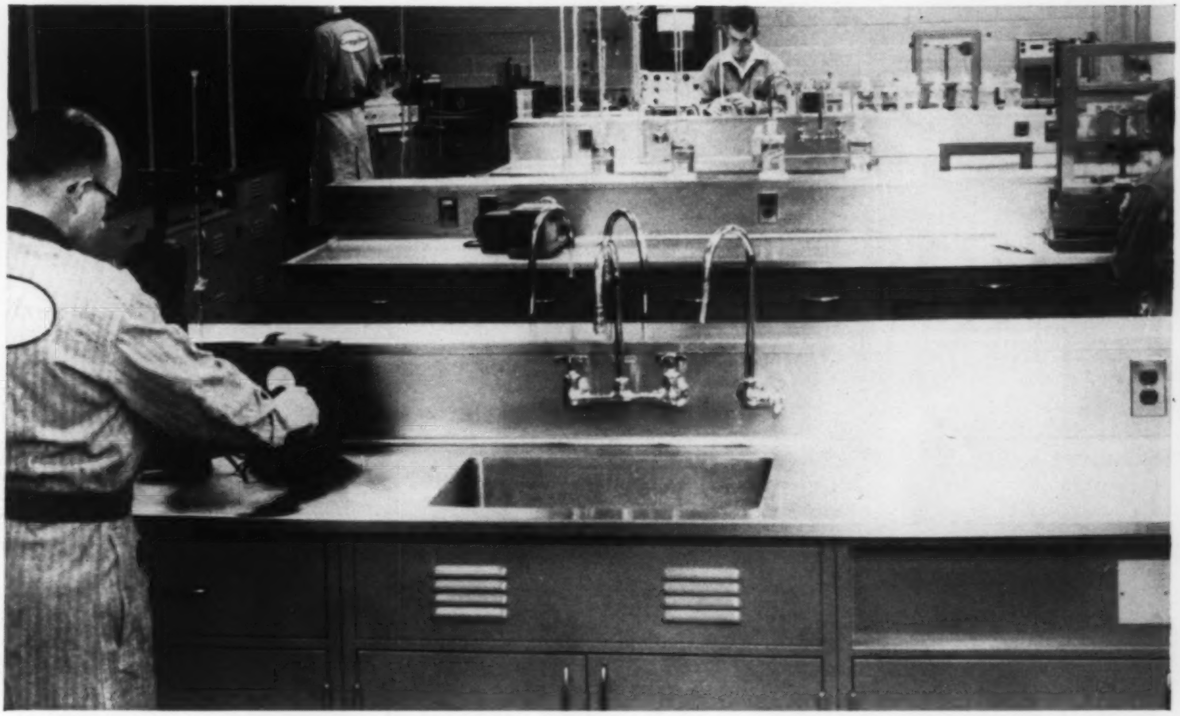
Textron, Inc., MB Manufacturing Co. Division 190
Thompson, H. I., Fiber Glass Co. 203
Thomson, Judson L., Manufacturing Co. 251
Timken Roller Bearing Co., The Back Cover
Tinnerman Products, Inc. 66
Torrington Co., The 13
Torrington Co., The, The Progressive Manufacturing Co. Division 261
Trent Tube Co. 67
Tuthill Pump Co. 183

Union Chain and Manufacturing Co., The 216
United States Graphite Co., The, Division of The Wickes Corporation 98, 99

Vari-Typer Corporation 250
Veeder-Root, Inc. 221
Versa Products Co., Inc. 262
Vickers Electric Products Division, Vickers, Inc., Division of Sperry Rand Corporation 114
Vickers, Inc., Division of Sperry Rand Corporation 61
Virginia Gear & Machine Corporation 50
Vulcan Electric Co. 244

Wagner Electric Corporation 106
Wales-Strippit Division, Houdaille Industries, Inc. 28
Weatherhead Co., The 126
Westinghouse Electric Corporation 53, 54, 55, 56, 57, 58, 71, 72, 73, 226, 227
Westinghouse Electric Corporation, Gearing Division 53, 54, 55, 56, 57, 58
Westinghouse Electric Corporation, Standard Control Division 71, 72, 73
Whitney Chain Co. 232
Wickes Corporation, The, The United States Graphite Co. Division 98, 99
Wickwire Spencer Steel Division of The Colorado Fuel & Iron Corporation 64, 65
Wiegand, Edwin L., Co. 210
Wiremold Co., The 266
Wittek Manufacturing Co. 222
World Bestos, Division of The Firestone Tire and Rubber Co. 231

Engineers Available or Wanted 266



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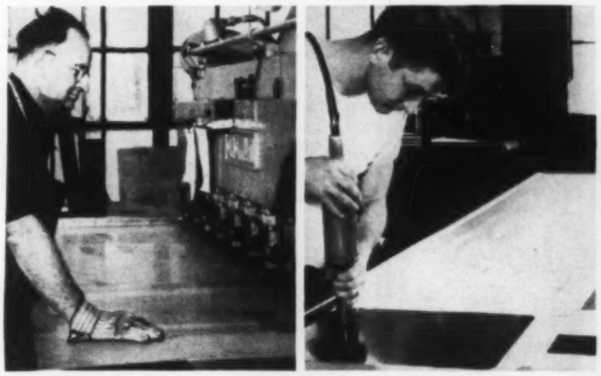

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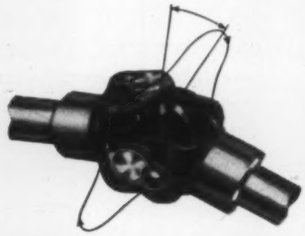

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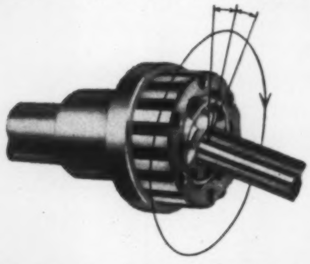

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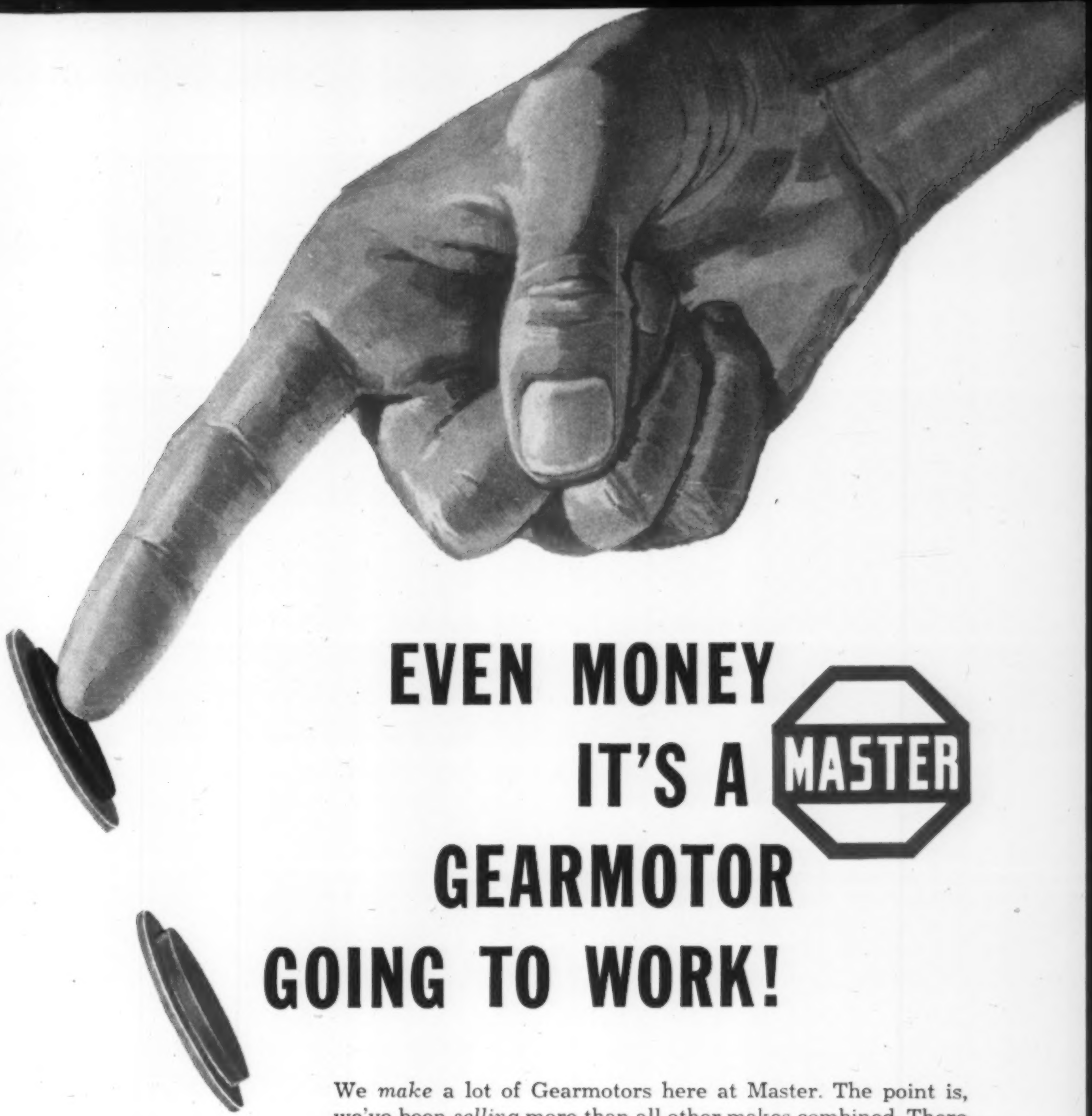

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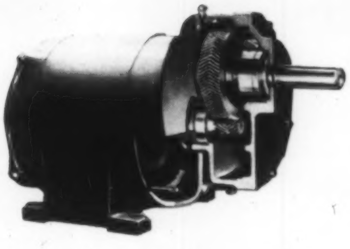

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Circle 402 on Page 19

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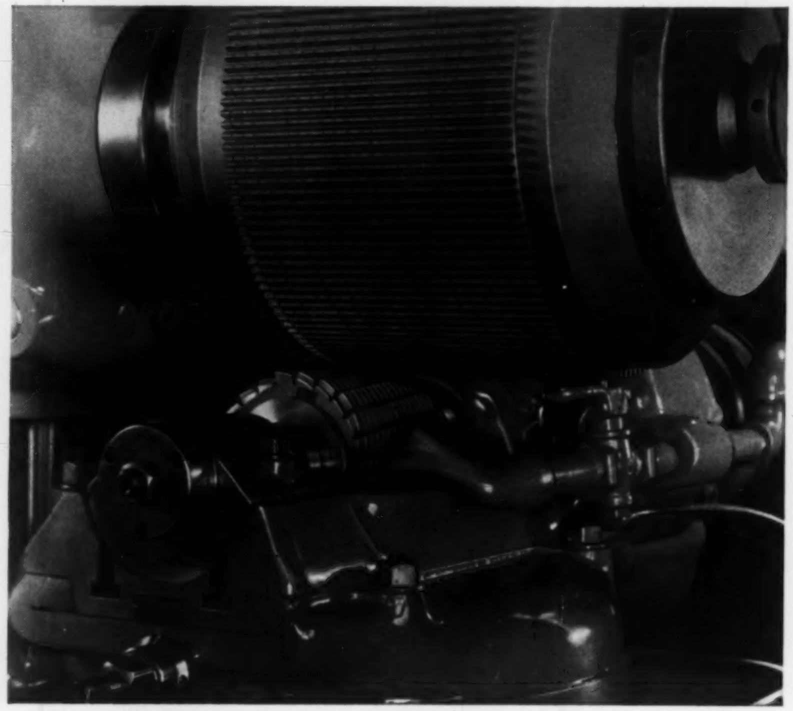

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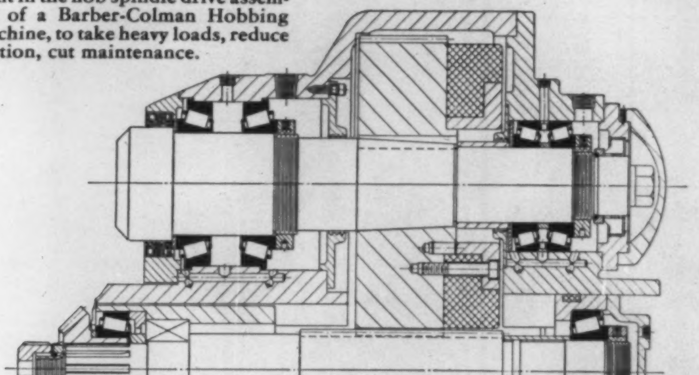

This symbol on a product means its bearings are the best.

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Circle 403 on Page 19